Mining Geology ...

TRANSACTIONS

of the

MINING and GEOLOGICAL INSTITUTE

of

INDIA

VOL. IV. - 5

EDITED BY

THE

HONORARY SECRETARY.

CALCUTTA:

PUBLISHED BY THE INSTITUTE AND PRINTED AT THE BAPTIST MISSION PRESS.

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Transactions

of the

Mining and Geological Institute of India.

Vol. IV—Part I.

Annual Meeting, 1909.

The annual ordinary and general meetings of the Mining and Geological Institute of India were held in the rooms of the Asiatic Society of Bengal, 57, Park Street, Calcutta, on Friday, January 29th, 1909, Mr. W. Miller, the retiring President, presiding over a large attendance.

The President opened the proceedings by welcoming the members to the annual meeting, which might be called the fourth annual meeting, and remarked that it augured well for the Institute to see so many members present. The first business was to appoint two scrutineers to examine the voting papers. For that purpose he moved that Mr. L. L. Fermor and Mr. R. R. Simpson be appointed scrutineers.

The Hon. Secretary (Mr. H. G. Graves) then read he minutes of the last meeting, and these having been adopted, he read the annual report of the Council, as follows:—

REPORT OF COUNCIL, 1908.

The Council have the honour to present the third annual report on the working of the Mining and Geological Institute of India.

2. During the year the membership has again largely increased as is shown by the following table which gives the numbers since the Institute was started :—

	1906	1907	1908	Net Increase in 1908.
Patron	1	1	1	..
Ordinary Members ..	156	187	219	32
Associate Members ..	8	16	18	2
Associates	3	7	11	4
Honorary Members ..	2	8	8	..
Subscribers	2	6	10	4

3. The following list shows the names and addresses of those who have joined the Institute during the year 1908 :—

Ordinary Members.

W. H. Bates, Mechanical Engineer, (speciality) Mining Machinery. C/o Messrs. Burn & Co., Ld., Howrah.

T. H. Bennertz, Mining Engineer. Holder of 1st class certificate of competency. Kulti, Burdwan.

D. Blair, Colliery Manager. Chowrassie Colliery, Dishergarh, *viâ* Barakar, E.I.R.

A. W. Bleeck, Mining Geologist, Ph.D., F.G.S. 5, Rainey Park, Ballygunge, Calcutta.

L. M. Chaudhuri, Colliery Manager. Lakurka Colliery, Katrasgarh, E.I.R.

W. C. Clements, Mine Manager. Holder of 1st class certificate under Indian Mines Act. Khost, N.-W. Ry., Baluchistan.

F. C. Dwane, Asst. Colliery Manager. Holder of 1st class certificate under Indian Mines Act. A.M.I.M. & M. Singareni Collieries, Yellandu, Deccan.

C. S. Fawcitt, F.C.S., Analytical Chemist and Assayer, 11, St. Mark's Road, Bangalore.

E. N. Forbes, Mining Contractor. Dhadka House, Asansol.

A. Ghose, F.C.S., Analytical Chemist and Mine Manager. Betamcherla, Kurnool.

J. W. Greener, Mining Engineer. Holder of 1st class certificate of competency under English Coal Mines Act. C/o Messrs. Bird & Co., Calcutta.

R. H. Haggie, A.M.I.C.E., M.I.E.E., M.I.M. & Ch.E., M.I.M.E. Electrical and Mechanical Engineer. Tyneholm, Maldstone, Middlesex.

H. W. Hallifax, Asst. Engineer, P.W.D., Irrigation. Nagpur. C.P.

H. Herklots, Asst. Mine Manager. Ramandrug, *viâ* Hospet, S. M. Ry., Madras.

R. Heron, Asst Colliery Manager. Holder of 1st class certificate. Jamuria Colliery, Nandi P.O., *viâ* Raniganj, E.I.R.

R. G. Higby, Mining Engineer. Holder of English certificate. Baltic House, 27, Leadenhall Street, London, E.C

W. Howarth, Colliery Manager. Nursamooda, Asansol, E.I.R.

F. T. Howes, Colliery Manager. Holder of 1st class certificate of competency under English Mines Act. Singareni Collieries, Yellandu, Deccan.

W. A. Ironside, A.M.I.M.E. Commercial Manager, Bird & Co.'s Coal Dept. C/o Messrs. Bird & Co., Calcutta.

J. W. Jervis, Geologist, Supdt., Mineral Dept., Bikanir State. Deshnook P.O., Bikanir.

W. E. Lawrie, Colliery Manager. Holder of 1st class certificate of competency under English Mines Act. Manjhiara, Asansol.

E. Massilamani, Assoc. Royal College of Science in Geology, B.Sc. (Honours) of London, F.G.S. Trivandrum, Travancore.

A. Murdoch, Colliery Manager. Holder of 1st class Mine-Manager's certificate. Dishergarh P.O., *viâ* Barakar, E.I.R.

T. C. Murray, Mining Engineer, M.I.M.E., Student, M.I.M.M. Colliery Manager. Chasnalla Colliery, Jharia, E.I.R.

J. A. Oliver, Mining Engineer. Holder of 1st class certificate of competency. Bhulanbararee Colliery, Jharia, E.I.R.

A. H. M. Paton, Colliery Manager. Holder of 1st class certificate. Bengal Iron and Steel Co., Ld., Kulti, E.I.R.

W. H. Phillips, Consulting and Mining Engineer, Mineral Estate Agent. M.I.M.E., Mem. Nat. Assn. Coll. Managers, Mem. Mid. Mining Officials Assn., Certified Colliery Manager. Palana Colliery, Deshnook P.O., Bikanir.

G. N. A. Pitt, Certified Colliery Manager. M.I.M.E., Mem. Nat. Assn. of Coll. Managers. Banksimulla Colliery, Charanpur P.O., *viâ* Asansol, E.I.R.

E. G. Seth Sam, Mining Engineer. Colliery Manager with 1st class certificate of service. Teetulmoorie Collieries, Sijua, E.I.R.

P. Sampat Iyengar, Geologist. Mysore Geological Department, Bangalore.

Geo. D. Scott, Colliery Manager. Holder of 1st class certificate under Indian Mines Act. Shunga Mahal Colliery, Nirshachatti P.O., *viâ* Barakar, E.I.R.

H. Kilburn Scott, Mining Engineer. M.I.M.M., M.I.M.E. 46, Queen Victoria Street, London, E.C.

F. M. Short, Electrical Engineer, 103, Clive Street, Calcutta.

S. G. Stromquist, Mining and Metallurgical Engineer, A.R.S.M., A.I.M.M. C/o Mysore Manganese Co., Ayanur, Shimoga, Mysore.

J. Thomas, Colliery Manager. Holder of 1st class certificate under English Coal Mines Act. Bustacolla Colliery, Jharia, E.I.R.

C. L. Watson, Colliery Manager. Holder of 1st class certificate under English and Indian Mines Acts. Bhowra Colliery, Jharia, E.I.R.

H. L. Wilkinson, Mining Engineer. Holder of 1st class Mine Manager's certificate, M.I.M.E. Chara P.O., *viâ* Raniganj, E.I.R.

J. R. R. Wilson, Chief Inspector of Mines in India. M.I.C.E., M.I.M.E., F.G.S. 9, Dacre's Lane, Calcutta.

Associate Members.

W. Davies, Assistant, Messrs. Ambler & Co. Dharhara, E.I.R.

J. H. Evans, Mechanical and Electrical Engineer. Rajhara, Palamau, E.I.R.

Associates.

A. Krishnaiya, c/o A. Subramani Aiyar, Esq., Rayegi Street, Nellore.

C. E. Low, Member of C. P. Commission. I.C.S. Nagpur, C.P.

B. Pestonjee, Merchant and Contractor. Prospector of Manganese Mines. Nagpur, C.P.

R. G. D. Thomas, 8, Mission Row, Calcutta.

Subscribers.

The Aldih Coal Co., Ld., 2, Clive Ghat Street, Calcutta.

Anderson Wright & Co., 22 Strand, Calcutta.

The Equitable Coal Co., Ld., 2, Clive Ghat Street, Calcutta.

Macneill & Co., 2, Clive Ghat Street, Calcutta.

Honorary Members.

Sir A. H. L. Fraser, K.C.S.I., M.A., LL.D.

James Grundy, Walthew House Farm (Crooke Delivery), Wigan, Lancashire.

4. The Council note with regret the loss of two ordinary members by death, Mr. G. M. Darby of the Standard Coal Co., Jharia, and Mr. D. Bone of the Bhuggutdih Colliery, Dhanbaid. Two members have also resigned, Mr. R. H. Morris and Mr. A. M. Thaddeus.

5. Meetings of the Institute were held as follows:—

Annual General Meeting, Calcutta, 31st January, 1908.
Ordinary General Meeting, Calcutta, 1st February, 1908.
,, ,, ,, Sodepore, 2nd March, 1908.
,, ,, ,, Jharia, 13th July, 1908.
,, ,, ,, Dishergarh, 23rd November, 1908.

The meeting at Sodepore was held by invitation of the Bengal Coal Company, Limited, and that at Dishergarh by the invitation of the Equitable Coal Company, Limited.

6. At the Annual General Meeting the President delivered a Presidential Address, and at the subsequent meetings the following papers were read and discussed:—

(*a*) Elementary theory of Cylindrical Dams to resist fluid pressure in Mines. By Mr. W. T. Griffiths.

(*b*) The Kodarma Mica Mines and Mining. By Mr. A. A. C. Dickson.

(*c*) Coal and the Smoke Nuisance in the 17th Century. By Mr. R. P. Ashton.

(*d*) An Ignition of Coal Dust. By Mr. G. N. A. Pitt.

(*e*) Central Power Stations for the Coal-fields. By Messrs. W. A. Lee and A. G Marshall.

(*f*) Longwall Method of Working Coal at the Sitarampur Coal Company's Nursamooda Colliery. By Mr. W. Howarth.

(*g*) Mine Dams. By Mr. W. T. Griffiths.

7. Three parts of the Transactions have been issued, forming part 2 of Vol. II and parts 1 and 2 of Vol. III, under the editorship of the Honorary Secretary. Vol. II, part 2, was issued to the members on the 25th January, Vol. III, part 1, on 15th July and Vol. III, part 2, on 30th November 1908.

8. Eight Council Meetings have been held during the year for election of members and transaction of the current business of the Institute. The Raniganj Map Committee has also pursued its work and an expert geologist from the Geological Survey is now in the field.

9. With reference to the proposition made by Mr. R. P. Ashton at the Annual General Meeting, held on January 31st, 1908, that the Institute be incorporated under the Indian Companys Act of 1882, the Council has to report that, in the opinion of the legal advisers of the Institute, the necessary formalities had not been completed according to the rules by which the Institute was governed at the time and that consequently it is necessary to place the question again before the members before completing the registration of the Institute. The matter is now in the hands of the honorary solicitors, Messrs. Orr,

Dignam & Co., who have been requested to take the requisite steps in the matter.

10. The prize offered by the Government of India for the best paper read before the Institute was awarded to Messrs. W. H. Pickering and R. R. Simpson for their joint paper on "Fighting a Colliery Fire."

11. The Council note with satisfaction that Sir Thomas Holland, K.C.I.E., F.G.S., F.R.S., A.R.C.S., Director of the Geological Survey of India and their first President, has been admitted to the Most Eminent Order of the Indian Empire as Knight Commander.

12. The financial statement shows that the position of the Institute is satisfactory. The revenue of the Institute for 1908 was Rs. 8,638-0-2, the expenditure Rs. 3,388-14-9, leaving a balance of Rs. 5,249-1-5. In addition Rs. 1,290, the realisation of entrance fees, has been credited to Capital.

MINING AND GEOLOGICAL INSTITUTE OF INDIA.

FINANCIAL STATEMENT for the year ended 31st December, 1908.

	Rs.	A.	P.	Rs.	A.	P.	Rs.	A.	P.	Rs.	A.	P.
CAPITAL ACCOUNT—												
Balance of last year's account ..	..	..	..	6,090	0	0						
Less entrance fees for 1907 not recoverable	..	..	..	60	0	0	6,030	0	0			
Entrance fees of 38 Ordinary Members	..	..	..	1,140	0	0						
,, ,, 2 Associate ,,	..	..	..	30	0	0						
,, ,, 4 Associates ..	..	..	..	120	0	0	1,290	0	0	7,320	0	0
RESERVE ACCOUNT—												
21 Life Members' subn. paid in advance	..	..	..	..	..	..	..	..	..	3,000	0	0
REVENUE ACCOUNT—												
RECEIPTS.												
Balance of last year's account ..	..	..	..	5,675	10	4						
Less SUBSCRIPTIONS for 1907 not recoverable	..	..	..	45	0	0	5,630	10	4			
SUBSCRIPTIONS for 1908—												
216 Ordinary Members @ Rs. 30 each Rs. 6,480												
3 ,, ,,@ ,, 15 ,, ,, 45												
18 Associate ,,@ ,, 15 ,, ,, 270												
11 Associates @ ,, 30 ,, ,, 330												
10 Subscribers ,, 150	7.275	0	0									
Interest from the National Bank of India	592	4	2									
Sale of Books	770	12	0	8,638	0	2						
EXPENDITURE.												
Advertising, Printing and Stationery	1,680	10	3									
Postages and Telegrams	385	9	0									
Dinner Account	185	8	0									
Raniganj Coal-field Geological Map Account	131	0	0									
Charges, General	526	3	6									
Establishment	480	0	0	3,388	14	9	5,249	1	5	10,879	11	9
TOTAL RS. ..	..	..	..	..	..	..	..	..	..	21,199	11	9

	Rs.	A.	P.
Cash with the National Bank of India	4,474	6	6
Cash with the National Bank of India (Fixed Deposit)	15,000	0	0
Cash with Honorary Secretary ..	7	3	3
Outstanding Subscriptions, 1907..	150	0	0
,, ,, 1908..	555	0	0
,, Entrance fees, 1908	60	0	0
Value of Publications in Stock ..	400	0	0
Outstanding Bills	276	4	0
Sundry As ets	276	14	0
TOTAL RS. ..	21,199	11	9

Examined and found correct.
LOVELOCK & LEWES, *Chartered Accountants.* } *Auditors.*

H. G. GRAVES,
Honorary Secretary.

Calcutta, 19th January, 1909.

The President, in moving their adoption, said that both the report and the financial statement spoke for themselves, and showed that the year just ended had been a very satisfactory one indeed.

There had been a fairly good increase in the membership of the Institute. Ordinary Members had increased by 32, Associate Members by 2, Associates by 4 and Subscribers by 4. If they went on increasing yearly at that rate they would be a very successful Institute indeed. The financial statement also was very satisfactory but he would leave that to be dealt with by the seconder.

Mr. R. P. Ashton, in seconding the motion, said that Mr. La Touche had acted as Treasurer during the year but, in his absence, he had been asked by the President to offer some remarks upon the accounts. These were presented in the usual form. They would notice that there was continual growth in the financial position. The capital account, which was the accumulation of entrance fees had increased from Rs. 6,090 to Rs. 7,320; the reserve account which consisted of life member's subscriptions paid in advance had risen from Rs. 2,370 to Rs. 3,000. The income of the Institute had increased from Rs. 7,514 to Rs. 8,638, and the expenditure had decreased owing to less outlay under several heads, from Rs. 4,296 to Rs. 3,388. The net income of the Institute had in consequence increased from Rs. 3,217 to Rs. 5,249, and there was now a balance to the credit of revenue of Rs. 10,879. The funds were disposed of as to Rs. 4,474 as credit balance in the National Bank, and as to Rs. 15,000 as fixed deposit in the same Bank. Last year he had asked for suggestions from members as to the employment of these surplus funds, and mentioned that the Council proposed to institute a Lending Library. Nothing, however, had yet been done, and meanwhile the funds were accumulating.

The report was adopted.

The President then opened and read the annual report of the Judging Committee on the prize papers which was as follows:—

REPORT OF A MEETING OF THE JUDGING COMMITTEE ON PAPERS.

Members:—MESSRS. R. J. BROWNE, P. BRÜHL, H. G. GRAVES, H. H. HAYDEN AND G. C. LEACH.

A meeting of the Committee was held on Friday, the 15th January, 1909, at 2, Bankshall Street, Calcutta. There were present:—Messrs. H. H. Hayden, G. C. Leach and H. G. Graves.

The papers considered were those included in Vol. III, Parts 1 & 2 of the Transactions, *viz*:—

Elementary Theory of Cylindrical Dams to resist Fluid Pressure in Mines. By Mr. W. T. Griffiths.

The Kodarma Mica Mines and Mining. By Mr. A. A. C. Dickson.

Coal and the Smoke Nuisance in the 17th Century. By Mr. R. P. Ashton.

Central Power Stations for the Coal-fields. By Messrs. A. G. Marshall and W. A. Lee.

An Ignition of Coal Dust. By Mr. G. N. A. Pitt.

Longwall Method of Working Coal at the Sitarampur Coal Company's Nursamooda Colliery. By Mr. W. Howarth.

Mine Dams. By Mr. W. T. Griffiths.

It was considered that many of the papers were of very nearly equal merit and the Committee accordingly had much difficulty in coming to a decision. After some discussion it was considered by those present that the papers by Mr. Dickson on Mica Mining and by Mr. Howarth on Longwall Working should be bracketed together for the first place, and that the Government Prize of Rs. 500 should be equally divided between them.

(Signed) H. G. GRAVES.
,, H. H. HAYDEN.
,, G. C. LEACH.

The undersigned members of the Committee, who were unable to be present at the meeting, concur in the award.

(Signed) P. BRÜHL.
,, R. J. BROWNE.

The President then received the report of the scrutineers and announced that the list of members recommended by the Council as President, Vice-Presidents, Honorary Treasurer, Honorary Secretary and other Members of Council for 1909-10, had been adopted by the voters. It was as follows:—

President—

H. G. Graves, A.R.S.M.,
Secretary to Govt. of India, Inventions and Designs.

Vice-Presidents—

Thos. Richards,
Superintendent, Nandydroog and Balaghat Mines,

J. J. Turnbull, M.I.M.E., F.G.S.,
General Manager, East India Coal Company.

Honorary Treasurer—

T. D. LaTouche, B.A., F.G.S.,
Superintendent, Geological Survey of India.

Honorary Secretary—

H. H. Hayden, B.A., B.E., F.G.S.,
Superintendent, Geological Survey of India.

Members of Council—

G. F. Adams,
Inspector of Mines in India.

F. J. Agabeg,
General Manager, Apcar & Co.'s Collieries.

R. P. Ashton,
Kilburn & Co.

P. Bosworth-Smith, A.R.S.M.,
Superintendent, Tank Mine, Kolar Gold-Field.

A. Gregory,
Manager, Gopalichuk Colliery.

H. M. Hance,
Manager, Indian Manganese Co.

B. Heaton,
Principal, C. E. College, Sibpur.

S. Heslop,
Superintendent, New Beerbhum Coal Company.

F. C. Hughes, Major, I.A., F.C.S.,
Assay Department, Indian Mints.

G. C. Lathbury,
Manager, E. I. Ry. Collieries.

J. Mackintosh,
General Manager, Borrea and Oondal Coal Company.

G. F. Scott,
Chief Mining Engineer, Bengal Coal Company.

W. F. Smeeth, M.A., B.E., A.R.S.M., A.R.C.S., F.G.S.,
State Geologist and Chief Inspector of Mines, Mysore.

J. R. R. Wilson, M.I.C.E., M.I.M.E., F.G.S.
Chief Inspector of Mines in India.

R. Wordsworth,
Manager, Bellarpur and Warora Mines.

Mr. C. H. McCale then moved a vote of thanks to the retiring President and Council for their services during the past year.

Mr. T. Chrystle, in seconding, said that he was sure that all those, who were here last year, were greatly pleased with Mr. Miller's practical address, and the Council also merited a vote of thanks. The President amply fulfilled his promise to carry out the duties of his office and to promote the welfare of the Institute.

The vote was carried with acclamation.

Mr. W. Miller, in replying, said that it had been a very great pleasure indeed to him to preside over the meetings of the Institute. He was only sorry that his term of office had terminated, but it could not be otherwise since he did not believe in the absent President, and he was going Home for the best part of the current year. They had been able to elect for the ensuing year a gentleman who would, he was sure, do honour to the position of President of the Institute. Although he was no longer an office-bearer in the Institute he would always continue, as long as he remained in the country, and even after his retirement, to do his best for and to take an interest in the Mining and Geological Institute of India. Their Institute was now on a very firm basis and should go on prospering from year to year.

Mr. H. G. Graves, the new President, then took the chair and delivered the following address:—

Presidential Address.

BY

H. G. Graves, A.R.S.M.

GENTLEMEN,

It is the custom of this Institute that the newly-elected President, on his installation in the Chair, should deliver an address dealing generally with any subject or subjects that he may choose and presenting his opinions for your approval. It can not be said to be the custom from time immemorial, for the existence of our Institute has been short, but it is the use of most of our kindred societies, and as the Manx proverb has it "Custom must be indulged by custom or custom will die."

Before, however, I endeavour to place my lucubrations (to follow that good word of Isaac Bickerstaff) before you, allow me to tender to you my most sincere thanks for the honour that has been conferred upon me by my nomination and election to this Chair. As your Honorary Secretary for the last two years I endeavoured, and hope succeeded, in doing some good work for the Institute, and I can assure you that my attempts in that direction will not be minimised in my present position.

Our line of Presidents has been short. The first, Sir Thomas Holland, then Mr. Holland, represented the geological aspect of our Institute and he has strong leanings to the economic side on which the development of India so largely depends. Our second President, Mr. Miller, my immediate predecessor, stood for the coal mining industry. He too, as is becoming in the manager of a successful colliery company, has also strong leanings to the economic side of things; for upon them dividends depend. Geology and coal mining being thus accounted for, leave places for metal mining and metallurgy, but it is not for me to claim to represent either of those subjects in the expert way that has been done for geology and coal mining. My vocation in life has led me rather away from the absolute doing of things and has kept me in tension as to matters that may possibly be practical in the future. Nearly twenty years in the British Patent Office and slightly over four years as head of the Patents Office in India have made of me somewhat of a jack of all trades. Proverbially Jack is master of none, and the impeachment must be admitted. For it must be acknowledged that a man, dealing at one moment with a specification of a locomotive, and then with a loom, followed in rapid succession by a harvesting machine, a metallurgical process, an electric winding engine, a wireless telephone, a printing press,—with interludes of patent golf balls, hair pins, padlocks, gas and gaiters—can scarcely give an authoritative opinion on any recondite point of practical working in all the trades or professions from practical experience of them. Yet in that very weakness, if the bold assertion be pardoned, lies the strength of my position. For with the wide, even if somewhat superficial, experience thus gained it is comparatively easy to say what has been done in one department and to draw some inferences or conclusions applicable to some other technical or scientific matter. Knowledge of one's own profession is, of course, essential, but it is liable to work in one groove. A liberal education, whatever the nature of its liberality, enables a clearer perception of things to be attained. Education never finishes. To the end of our days we shall always be picking up pebbles on the shores of knowledge. You, who are coal-miners, do not spend all your time on the extinct carboniferous sea, but you know full well that there is still something to be gathered from miners of manganese, gold, mica and even from engineering workshops.

Before going farther it may be of some interest to recapitulate briefly a few facts regarding patents for inventions. That form of monopoly took its rise in England and were first legalized by a statute of James I passed in the year 1623, though there were many earlier patents in existence, granted by the Crown. In Great Britain there has been a continued succession of Patent Acts, dated 1835, 1839, 1844, 1852, 1853, 1859, 1865, 1870, 1883, 1885, 1886, 1888, 1901, and 1902. All these are now replaced by the existing Act of 1907 which has been so widely discussed, and from which so much has been hoped, on account of what are known as the compulsory working provisions, which necessitate that patents must be worked in the country or be liable to revocation. It was only in December, 1908, that the first result of these provisions was obtained on an application to the Comptroller-General of Patents. The case was this:—A Mr. Hatscheck, owner of English and foreign patents for certain kinds of tiles, gave licenses for their manufacture in France, Germany and Belgium. Works were erected in those countries, and those in Belgium were intended to supply the English market. They could prevent import from other countries and control the price generally in England, where the patent prevented manufacture, as no licenses were granted under it. The patentee offered to give English licenses, but did not do so, and as a matter of fact, could not have done so under the terms of the Belgium license. Nor were any effective steps taken to start the manufacture in England. Accordingly it was held that the patent rights were exercised in such a way that no effectual return was obtainable in England for the grant, and the patent was therefore revoked forthwith. The judgment of the Comptroller will repay careful perusal. From the comments in the *Times* of December 19th and 21st, 1908, and *Engineering* (December 18th, 1908) and other papers it is evident that the law enables a fair and equitable view to be taken of the requirements of any patentee, that if he gets a monopoly for his inventive facilities he must utilise it for the benefit of the public. This new provision of patent law in the United Kingdom has often been characterised as a protective measure, but properly speaking it should not be regarded in that light. It merely prevents any patentee, whether he be a foreigner or a native of the country, from taking up a dog-in-the-manger attitude. The form of patent has always specified that the grant is on the condition that it is not contrary to law nor prejudicial or inconvenient to the subjects of His Majesty. Tenderness for the inventor and a series of judicial pronouncements, of which the tendency was not at first seen, had frittered away these rights and the patentee, especially the foreigner, presumed on his position, thus fortified. Now, however, the rights of the public are restored and the patentee is merely allocated again in his proper place. This interpretations of the new law more than affirms that position; it removes all disabilities not only from the home manufacturer, but also from all others outside the country. Further it allows the consumer to obtain the material freely from any source and, in fact, it has proved to be free trade provision *in excelsis*.

In India patent legislation originated in 1856, but the first Act, owing to an informality in the procedure, was not sanctioned by the Secretary of State. Subsequently it was amended and came into force in 1859. Thirty years later, in 1888, it was replaced by the existing Inventions and Designs Act which followed in many respects the English statute of 1883. When India first took up the question of patent legislation, the general attitude towards the inventor was one of great benevolence, and rightly so. The marvellous development of arts and manufactures in the earlier part of the century had proved the inventor to be a public benefactor all over the world. As has been seen from the previous remarks, however, he ultimately proved to be an oppressive benefactor in individual cases, but naturally that was not foreseen at the time. The aim was then to encourage the inventor in every way and this, in India, was carried far beyond the limits laid down in English law. The result is that now an alleged infringer of the exclusive rights to the use of an invention is unable, except under special circumstances, to defend himself on the natural ground that the grant was improperly obtained or is invalid. At the same time the inventor suffers under certain disabilities and generally the procedure is antiquated and more cumbrous than it need be. With a view of remedying this state of affairs a draft bill to amend the present Act has been prepared and published for criticism. Anyone interested may see or obtain a copy at the Patents Office, 2, Bankshall St., Calcutta.

Of course, India at present is not a first class manufacturing country in the same sense as England, the United States, Germany or France. New inventions play a secondary part here. The manufacturer and the works manager have all their time taken up in manufacturing and managing. If they want machinery, they get it mainly from abroad where the latest and most improved types are more readily available, and where there are specialists ready and willing to produce designs suited to new conditions and circumstances. The wants of the small maker and the home worker are fewer and their means are limited. They are satisfied only too often by second hand appliances or crude makeshifts when the external manufacturer has not turned his attention to supply their needs. But that state of affairs has been slowly changing. Already there are many works in the country which make things of improved design on a wholesale scale all over India. The number is increasing and will increase by leaps and bounds in the near future. At present many of these things are of excessive cheapness and of correspondingly faulty or ineffective construction, demanding a useless waste of labour for their operation. That hoary-headed anachronism, the idea that cheap labour is cheaper than labour-saving appliances, is disappearing. With its departure the future of India as a manufacturing country is assured.

In the past almost entirely, and in the present partially, local demands have found satisfaction from local sources with the natural consequence that really skilled labour is scarce. As this condition changes, skill, and consequently knowledge with power of assimulation, followed by potency for origination, all develop. At present the inventive faculty of the native of this country except in rare and individual cases is small, at least in respect of patents, while the foreign resident is too busy to exercise it even if he has it. The native follows custom. The other utilises foreign resources. Further, the foreign inventor seldom finds it worth his while to protect his invention in India, knowing full well that it will have to be brought to perfection by experiment in his own country; and in any case it is not likely to be manufactured here. Hence the number of applications for patents and the number of patents granted is small in India—very small in fact as compared with other countries.

According to the report of the United States Commissioner of Patents for 1907 (the latest available) the total number of patents granted up to that date in the different countries of the world is as follows (figures for 1907 estimated):—

Countries.	To 1870, inclusive.	1871 to 1907.	Total.
Argentina	83	6,704	6,787
Australia	..	4,172	4,172
Austria	..	50,350	50,350
Austria-Hungary . ..	15.350	67,583	82,933
Bahamas	..	2	2
Barbadoes	..	137	137
Belgium	35,044	176,217	211,261
Bolivia	42	65	107
Brazil	185	5,622	5,807
British Guiana	32	94	126
British Honduras	1	19	20
Canada	4,081	108,576	112,657
Ceylon	58	639	697
Chile	266	1,557	1,823
Colombia	..	973	973
Congo Free State	..	184	184
Costa Rica	..	52	52
Denmark	464	17,368	17,832
Ecuador	..	10	10
Fiji Islands	..	33	33
Finland	112	2,877	2,989
France	103,934	291.338	395,272
Germany	9,996	202,084	212,080
Great Britain	53,408	329,709	383,117
Guatemala	..	57	57
Hawaii (prior to August 12, 1898) ..	..	148	148
Hongkong		159	159
Hungary	..	36,409	36,409
India	445	9,118	9,563
Carried over ..	223,501	1,312,256	1.535,757

Countries.	To 1870, inclusive.	1871 to 1907.	Total.
Brought forward ..	223,501	1,312,256	1,535,757
Italy and Sardinia	4,723	80,195	84,918
Jamaica	22	192	214
Japan	..	13,235	13,235
Leeward Islands	..	20	20
Liberia	..	2	2
Luxemburg	..	7,183	7,183
Malta	..	67	67
Mauritius	113	265	378
Mexico	22	7,251	7,273
Netherlands	4,535	..	4,535
Newfoundland	40	364	404
New South Wales	236	11,740	11,976
New Zealand	109	11,319	11,428
Norway	737	17,922	18,659
Paraguay	..	75	75
Peru	..	160	160
Portugal	245	5,326	5,571
Queensland	67	6,368	6,435
Russia	1,464	17,796	19,260
St. Helena	..	4	4
South African Republic	..	1,262	1,262
South Australia	123	6,221	6,344
Spain	..	38,348	38,348
Straits Settlements	..	184	184
Sweden	1,629	25,186	26,815
Switzerland ..	..	39,473	39,473
Tasmania	43	2,426	2,469
Transvaal	..	1,581	1,581
Trinidad	6	176	182
Tunis	..	639	639
Turkey	..	1,640	1,640
United States	120,573	765,062	885,635
Uruguay	..	320	320
Venezuela	..	216	216
Victoria	822	12,463	13,285
Western Australia	..	3,524	3,524
TOTAL ..	359,010	2,390,461	2,749,471

These are the latest figures generally available. At the present rate the total will exceed 3,000,000 before the end of the year 1910.

Up to the end of last year, 1908, there have been granted in India 7,387 patent rights on a total number of 9,510 applications, made under the present Inventions and Designs Act, which came into force on July 1st, 1888. Statistics of the yearly applications have been as follows:—

	Resident in India.		Foreigners.	Total.
	Natives.	Others.		
1908	57	142	352	551
1907	63	135	417	615
1906	65	144	411	620
1905	71	143	372	586
1904	67	135	350	552
1903	47	126	363	536
1902	53	144	327	524
1901	46	140	310	496
1900	45	142	305	492
1899	34	118	329	481
1898	45	126	310	481
1897	43	114	294	451
1896	49	124	287	460
1895	42	137	238	417
1894	32	143	200	375
1893	22	177	176	375

The following extract from a recent report of the Patents Office may be of interest, and the relative figures have not changed greatly since that date :—

"In respect of invention in the country itself Calcutta and its suburbs were the most fertile, producing 67 applications supplemented by nine only from the rest of Bengal. In Bombay conditions were reversed, the town only giving

13 out of the total of 45 applications. Both from Bengal and Bombay, there were 19 applications from natives, leaving 57 and 26, respectively, for other residents. Madras and the Punjab each produced six native applications out of their totals of 26 and 16. The figures for the United Provinces are 5 out of 13, for Eastern Bengal and Assam 3 out of 7, and for the remainder of India 7 out of 26. The ratio of inventors to the population is very low in this country. Taking applications from residents only, approximately one application is made for every 2,000 inhabitants in the United Kingdom, 1,600 in the United States, and 3,000 in Germany. But in India the figure becomes 1,400,000 and, even at the best, does not get below 16,000 for Calcutta."

I hope I have not wearied you with these particulars as they are only part of a larger subject with which I wish to deal as shortly as possible.

At any particular period all reasonable inventions indicate what is intended to be done. They are a sequel of what has been done. With rare exceptions they are adaptations or developments of known ideas or principles to practical use, or are applications in a modified form of known means or appliances to different or extended purposes.

It will be in the remembrance of many, the sudden rise of penny-in-the-slot machine from about 1886. In their early days most people thought they were absolutely a novelty, but, as a matter of fact, they had been in a state of slow and obscure development during the previous 20 years or more. Even before that they were an outcome of the old tobacco box which used to stand on the table in the country hostelry and could only be opened by the insertion of a coin. And there is even a description of a device in ancient temples whereby the insertion of a drachma or some equivalent produced a quantum of lustral water. Thus you will see that the idea was there of old. It was developed only to meet a public want, and it is in that development, what spice of novelty there may be, exists. This is only one illustration, but it will serve to point one moral, that I wish to adduce. Ordinarily if any man wants anything he goes where he can get it. Too commonly, alas, he has to pay for it and the proprietor stands by to see that he does not get more than his anna's worth. But the proprietor, being ingenious to save himself trouble, puts a simple machine to take his place. The purchaser, being not altogether and always trustworthy perhaps, or requiring quicker and more effectual service, necessitates a refinement or improvement of that machine. And so the matter develops from small beginnings by gradual accretions, which pass through successive and repeated stages of further complications, alternating with renewed simplicity.

Here we have only the particular case of a vendor and a customer, but it is true generally. Something has to be made, or some operation to be performed. The work is done first of all by hand, then by simple appliances, and finally by machinery which contains many applications and developments of previously gained knowledge.

You may or may not agree with me entirely as to the amount of novelty that attends development on any particular line: but in this, at least, I am sure of your hearty agreement—that development is more likely to proceed rapidly if knowledge abounds. And that brings me to the next point "What man has done, man can do." But he can not do it well without the knowledge of what his predecessors have done, unless, indeed, he is to waste much thought and effort.

If anyone has a problem to face, the easiest course, of not endeavouring to meet it, has naturally to be put aside. Two ways are open. The matter may be tackled direct by the encounterer with his own unaided efforts, backed by such light of nature and exuberance of his own powers as he may possess. That is a waste of time. It is easier, as a rule, to draw on the experience of others as a preparation for the work. For us as geologists, mining engineers, and metallurgists, recourse may be had to our friends and acquaintances, to our text-books, to monographs, to transactions of societies and institutes such as our own, and to technical papers and periodical literature generally. Our own Transactions are as yet too small to afford much help except in a few subjects. But we have in them an unlimited field for development and mutual assistance. In his Presidential Address last year, Mr. Miller pointed out many subjects on which papers would be valuable and he called for free discussion. The speakers, following the reading of the paper not only bring out its strong points, but also elucidate the weak points and give much valuable supplementary information. How often have not the members seen little groups on the steps of the meeting room or in some odd corner discussing the paper apart from the rest at nineteen to the dozen, and sometimes at the top of their voices. If only those gentlemen will lift up their voices or wield their pens for the mutual benefit of us all, how glad we should be. We feel that they have something of value to contribute, and we want to have it *ek dum*. We must develop our discussions. It is not always necessary to talk in public. In fact there often is not time at our meetings. But there are always pens, ink and paper available after the meeting for written contributions on the papers. Destructive criticism alone is not so much use; constructive criticism and information should follow.

What man has done, man can do. It is a truism. Yet how often a statement of some result, contributed in good faith, is met by arrant incredulity. The next stage in its history is the belief that the author possibly can do or produce something which somehow is an exception that can not be attained elsewhere. For a novelty, those attitudes are more or less excusable, but they are so often taken up with regard to well-established knowledge. That should not be so. Circumstances differ I admit and there are prejudices to overcome. Mr. W. Howarth, for instance, when he introduced long-wall working at the Nursamooda Colliery, had many difficulties to encounter. Amongst other things he had to appease labour, and that was no slight thing as he was at one time chased by his hewers, picks in hand. Now those men prefer the long-wall system of which the advantages for India are many and obvious. His paper will show you some of them.

Even if he had failed, which he has not, one failure would not condemn the thing irretrievably, any more than one swallow makes a summer in England. *Post hoc, sed non propter hoc* is a motto which applies to the proverb as well as to the failure. The cause of the failure is often due, not to the system, but to some defect in carrying it out. A high rate of interest and a scarcity of capital, too great an expenditure on a superabundance of cheap labour with its corresponding waste, inefficiency of inspection and supervision, indifference of, or failure to reach, the purchaser,—these are but few of the items of non-success.

One of the first things that strikes the newcomer to this country, after he has become used to crows, kites, and bare bodies, is the absolute waste of labour that exists everywhere. Yet he hears from all sides of the scarcity of labour. The tea planter, the colliery manager, the mill owner, all unite in their cry for more men, women and children. Yet they go on paying increasing wages to the individual and their costs of production rise. I know the old tale of the wheel-barrow, but you have to learn the tale of the steam shovel. A manganese miner in the Central Provinces confessed the other day that it cost as much to get a ton of his ore from a shallow open working, as it did in America to get a ton of iron ore from a seam under a very heavy over-burden. For what is being done in this way by the use of steam shovels it would be worth your while to read the description in "Engineering" and Mining Journal of December 12, 1908, of the winning of a 20 *inch* ore seam by removal of 20 *feet* of cover.

Again the report of the Inspector of Mines shows the average outturn at a colliery as only 80 tons per head. In England it is three times that amount or 250 tons, while in the United States it is no less than 500 odd tons. The Americans admit their mines are easier than the English but they use machinery.

Again go to a jute mill in Calcutta. There are innumerable "byles," gharries and coolies. They can handle a ton of stuff for sums that may be reckoned in annas and pice. But ask yourselves whether a little more effectual plant would not save ground area and liberate labour to be more profitably employed in other directions. It will very shortly, even if it would not at this moment. The revolution may be slow but it will be effective and will proceed in a geometrical ratio.

You may think my ideas crude and you may laugh at my expression of them, but believe me, as Patents Secretary, I look forward to much machinery and many inventions as the solution of our problems. Allow me to return one moment to my point that "What man has done, man can do."

In Europe and America there are blast furnaces and open hearth furnaces. They produce steel and they sell it at a profit. And they do not hesitate to spend, especially in the United States. Mr. Schwab in giving evidence before the commission on tariff reform ("Iron Age," December 17, 1908) did not mince matters in this respect. European practice does not admit, to the same extent, the advisability of working quickly despite wear and frequent renewals. India goes to the other extreme and works so slowly, grudging every half-anna for repairs and replacements, but she puts up with "an intolerable deal of sack" in the form of labour. That would do in the past but it will not serve for a manufacturing India.

Other countries have made steel works pay. Therefore it can be done in India. That should be our attitude towards life. It is that adopted by the Tata Company with their new steel works now building at Kalimati. They can draw on the experience of past failures, but they need not, and have not, taken them as settling the question.

Finally, I would again ask you to bear in mind the saying "What man has done, man can do." Also "Help one another" by recording both your successes and failures in papers and discussions at the meetings of this Institute. And then like Napoleon eradicate the word "impossible."

The following paper was then read by the author:—

Proposed Electrification of Dishergarh Colliery.

BY

George Miller.

The proposal for the electrification of the Bengal Coalfields, which is now about to take practical form, appeared to be a good subject for a discussion by which any available information might be procured, and some data regarding the merits and demerits of the scheme might be obtained.

The valuable and instructive paper on the subject by Messrs. Marshall and Lee, read before this Institute in July, was but shortly discussed at the time perhaps for the reason that it was so thorough and the facts so convincing that members found it difficult to raise even a doubt in their minds as to the great advantages to be derived from such a scheme. Those who may not have found themselves so much impressed, had very little time or opportunity to procure sufficient data to enter into an intelligent and healthy discussion on the various points brought forward.

Having regard to the above fact it appeared to be a pity that such a valuable paper should be passed over without further discussion. To give the authors an opportunity of saying something more on the subject, thereby possibly converting any of the members that are still sceptical, this paper has been brought forward. It contains a few facts which are not altogether in favour of the electric power, so far as cost of pumping is concerned. Though this may be a matter for regret, the spirit which has led to the production of the following results must not be misunderstood. It is solely and purely for the purpose of a discussion, to elucidate the unvarnished truth with regard to the merits and demerits of the scheme.

In the author's opinion electric power will be of great advantage to collieries in general; and in some of the larger collieries, electrification of the underground pumps and haulages will become a necessity within a very short time. Some of the older concerns have already reached that stage. It will therefore be necessary for them either to support the scheme as at present put forward, or else face the expense of putting down the necessary generating plant.

Which of these alternatives will be the more economical is a question which might be brought up at some future meeting. At present the author is not in a position to go into this matter as it means procuring estimates and costs of plant and erection, etc., which are not yet in his possession; but anyone having such facts, would certainly render the members of the Institute a greatly appreciated service by writing a paper on the subject.

The following comparison is mainly based on particulars drawn from the colliery which is under the author's charge and of which he has a thorough knowledge. The special circumstances under which the underground pumps are worked are such as to give a most practical comparison of the two systems with regard to cost.

It is not proposed to deal with the question of lighting in this paper. Everyone knows the great advantages of a good electric light on a colliery or anywhere else where lighting is required. It has not yet become a necessity, and many persons are still inclined to regard it as a luxury on the colliery.

HAULAGE.

This may be considered of secondary importance so far as the collieries are concerned at the present time. Electric surface haulages cannot be said to be a necessity, though under most conditions they would doubtless be a great deal more economical.

Underground haulage engines, placed near the pit bottom, worked with air or steam, are in no way inconvenient. It has to be considered that the bulk of the Indian collieries depend entirely upon the steam pipes in the shafts and the exhaust from their haulage engines and main pumps for their ventilating current. To electrify these engines and pumps would destroy the ventilation. Other means would then have to be adopted to procure the lost air-current. This means of course the erection of a fan, and the cost of running it must be taken into account if the question of electrifying the pumps and haulages is to be considered. There is a limit, however, to the use of steam for underground work, and that limit should be the pit bottom pillar. Steam haulages in-bye and steam pumps in dip-workings are not in accordance with up-to-date mining. They increase the temperature of the mine which, in many instances, is surely high enough without the aid of steam. The roof becomes bad from moisture and heat. Condensation becomes excessive in the pipes, and the haulage engines and pumps become too weak for their duty owing to the great reduction in steam pressure. The manager makes daily enquiries about the water in the dip galleries. Labour in general is dissatisfied, and the output goes down. All this is due to steam being carried down into the workings of the mine, which extend until the limit of temperature has been reached; and then something radical has to be done.

Compressed air and hydraulic pressure might be considered the next best means for conducting power into the workings. Though much can be said in their favour, there is a limit also to their capabilities.

Electricity has been generally adopted for colliery work, and there seems to be no class of power-transmission more suited to the conditions than electricity. The smallness of space taken up by the cables whereby the power is transmitted, and their indestructibility, render it most convenient. The limit of distance to which the power can be transmitted is an unknown quantity. Therefore, when the limit of steam, compressed air, and all other means of power-transmission is reached, the only resource is electricity. Why then, when fitting a colliery of substantial area, should not a start be made with electricity.

In pumping and coal-cutting, it may be considered, the greater advantage will be derived from this electrical scheme, and accordingly the comparison may first be made with regard to the cost of pumping at the colliery in question. It is not proposed to electrify the main pit pumps at present installed, and therefore these are not taken into account.

There are in all 19 pumps at work in the underground workings ranging in sizes from 6″ × 3″ to 18″ × 8″, and all are of Tangye pattern. The duty of these pumps is to pump the water out of the dip galleries in stages to the water-level of the pit bottom, where the main pumps receive and force the water to the surface. The main pumps also deal with any surface water. This is caught by a drain and led direct to the main lodgment, thus freeing the dip pumps from dealing with any water except that actually given off in the course of working. The actual quantity of water dealt with by these pumps cannot be ascertained correctly, and the number of hours worked out of the 24 is a matter of assumption as in many instances the pumps are kept going when there is practically no water to pump. This refers more especially to the smaller pumps 6″ × 3″, their duty being to keep the main dip galleries free from water and to deliver it to the larger pumps which in turn deliver it to water-level, whence it is conveyed to the pit bottom. It is therefore difficult to procure exact data to go on in order to compare the actual work done by the pumps at present and the pumps proposed to be driven electrically.

In order to arrive at a fair comparison, the average working of the pumps at 10 hours in 24 has been taken, and the cost of working of the electric pumps has been calculated on that basis. The time taken is not considered excessive, and, if anything, is under rather than over the mark. A pump, whether electric or steam, is seldom worked at its full capacity owing to the many faults and flaws that occur in the ordinary course of work, such as leaky suction or delivery joints, worn buckets, badly packed rams, and commonest of all, perhaps, is the dip gallery miners' dustbin finding its way into the valves. With the best of supervision, these conditions exist with more or less frequency, and it must therefore be allowed that the various pumps will, at times, swallow up power while doing little or no actual work. However, a 10 hours' working day has been taken to cover all loss in these respects, and to deal with the quantity of water given off.

The steam pumps in this colliery cannot be considered economical; in fact they are quite the reverse. If they were placed in different positions, fewer pumps might do the same work. All are of the well-known Tangye type, and are not at all economical in the consumption of power. Yet they are suitable for colliery purposes in this country. Owing to their compactness there is but little to go wrong or break about them. It seems to be the second nature of an Indian coolie to find out any weak spots in a machine and to break them at the first opportunity.

The total capacity of these pumps, taken from the maker's tables, is equal to 80,400 gallons per hour, but the actual quantity delivered may be estimated at 50 % of that quantity, giving a total of 40,200 gallons. The electric pumps which it is proposed to install to do their work are somewhat smaller, and have a total capacity of 26,000 gallons. This reduction in capacity has been made purely on the side of economy in power and to have, as far as possible, the pumps continually at work under full load. The whole of the 19 dip pumps are worked from one air-compressor, the steam cylinder of which is 30 inches in diameter with a five-foot stroke, and the air-cylinder of the same dimensions. It runs at 40 to 45 revolutions per minute. It is a single high-pressure engine, with no expansion or condenser, and therefore is not so economical as a more modern compressor would be.

This compressor supplies the whole of the air for these dip pumps and nothing else, so that all the power used by the pumps is generated by this air compressor. The question of efficiency of the air-compressor or pumps need not be considered as it has no bearing on the result.

This compressor gets its power from two Lancashire boilers, 30 by 7 feet, constantly under steam. The cost of running two Lancashire boilers and air-compressors as generating plant is as follows. The average consumption of fuel, consisting of slack as raised from the colliery, for the two boilers over a period of 12 months, amounts to 374 tons per month.

Taking the average cost of above fuel at Rs. 3 per ton, the total cost in fuel per month is Rs. 1,122. The monthly cost of stores is estimated as follows:—

	Rs.
Two boilers, repairs and stores, at Rs. 20	40
Life of boiler 20 years, depreciation say	66
Six Firemen, at Rs. 9	54
Supplying dust and removing ashes	60
Fue	1,122
	1,342

By electrifying the pumps this cost will be wiped out so far as pumping is concerned.

AIR-COMPRESSOR.

The single compressor so far has been capable of generating the power required for the pumping, but a second compressor has been erected as a stand-by, and is now found to be necessary in order to ensure the pumping not being suspended at any time through mishap.

The second compressor is of a more improved type, having compound steam cylinders and a condenser. So far no test of this compressor has been made, the pumping during the year having been done entirely with No. 1 compressor. Since it is necessary to keep this compressor as a stand-by, the depreciation on same and repairs will have to be taken into account, against pumping cost.

	Rs.
Cost of No. 1 Compressor	6,000
Cost of No. 2 Compressor	12,375
	18,375

			Rs.
Life taken at 20 years, depreciation per month		..	76
Three Engine-drivers, at Rs. 10	do.	..	30
Stores, etc.	do.	..	100
Cylinder oil used in steam pumps, cost of which will be saved with electric pumps, per month		..	56
Extra cost of pump-man's wages over that of electric pumps, per month	..	..	150
	TOTAL	..	412
Cost of running boilers ..	..	..	1,342
	GRAND TOTAL	..	1,754
Cost per month of pumping by compressor		..	1,754

The depreciation of the pumps and connections has not been taken into account as I consider that the depreciation on proposed electric pumps will cover this.

COST OF ELECTRIC PUMPING.

To take the place of these 19 steam pumps it is proposed to install the following electric-driven pumps :—

Eight baling pumps, capacity 800 gallons per hour and a head of 100 ft.

Seven dip pumps, capacity 1,000 gallons per hour and vertical head of 400 ft.

Three main pumps of 6,000 gallons per hour, 400 ft. vertical head.

			Rs.
Running eight baling pumps for ten hours per 24, and 30 days per month, at An. 1 per hour each, costs per month ..	..	..	150
Running 7 dip pumps for 10 hours per 24, and 30 days per month, at As. 4 per hour each		..	525
Running 3 main pumps for 10 hours per 24, and 30 days per month, at Re. 1-4 per hour each		..	1,125
	TOTAL	..	1,800

This represents the total expenditure for power only, required for running these pumps.

The cost of stores has not been taken as any saving is not anticipated. The cost of stores, etc., for the steam pumps will balance that for electric pumps, excepting cylinder oil used for cylinder of steam pump ; and this has been entered against cost of running steam pumps.

Depreciation on pumping plant has not been considered in either case as it is thought that the depreciation on the electric pumps will cover that on the steam pumps now in use.

		Rs.
Cost of power for electric pumping	..	1,800
Cost of pumping with air-compressor	..	1,754
Total in favour of compressor, Rs. 46 per month.		

The above figures give a good idea of the difference in cost that may be expected in electrifying pumps already being worked by compressed air.

With steam pumps in underground workings, where the workings have extended, it is quite impossible to proceed on account of the great heat, condensation and inconvenience in the working places. These difficulties arise from the steam pipes and exhaust, and from the numerous and indispensable leaky steam joints. The question of steam pumps *versus* electric pumps therefore requires no consideration whatever.

The question accordingly arises whether it will be better, in the first instance, to put in a compressed air plant or an electric installation to take the place of steam. As has already been said, there is a limit to the distance compressed air can be conveyed. The further from the compressor the less efficient it becomes, and with long leads of piping the inevitable leaky joints must be taken into consideration. Though offering no practical inconvenience they reduce the efficiency of the plant considerably.

Though somewhat disappointed at the results of the comparison that has just been made the author still favours the installation of electric plant for pumping even with the slightly increased cost, and in his opinion the conveniences of such a scheme will more than justify the extra expenditure. Whether the costs have been correctly allocated may perhaps form a basis for discussion, for it is entirely with this view that the matter has been brought forward.

HAULAGES.

The question of electrifying the haulages may now be considered. It is proposed to put in three electric-driven haulages, Nos. 1, 2, 3, to replace three steam-engine haulages of the following dimensions:—

No. 1 Steam Cyl. 16″, Stroke 36″, drum 6ft. diam. Length of haulage 3,500 ft.; inclination 1 in 5.

No. 2 Steam Cyl. 16″, Stroke 2·6″, drum 5ft. Length of haulage 1,500 ft.; inclination 1 in 5.

No. 3 Steam Cyl. 14″, Stroke 42″, drum 6ft. Length of haulage 2,650 ft.; inclination 1 in 5.

The size and horse-power of the electric machines are not given, but they are designed to work on inclines of 1 in 5 as shown in the table below, which also gives the cost for power-working at the full loads:—

Cost per day.	Coal raised per day.	Length of incline.
	Tons.	Feet.
No. 1 Rs. 31-6	300	3,000
No. 2 ,, 11-3	200	1,600
No. 3 ,, 22-8	200	2,600

This, of course, cannot be taken as an actual working condition as it may be seldom indeed that these haulages may raise the quantities named; but a certain margin of power has to be allowed over actual requirements.

To arrive at a comparison of the two systems the average output of the steam haulages over the year has been taken at 25 working days per month, that being thought to be as fair a basis as possible to both systems. It is assumed that the cost of the power for the electric haulages varies in proportion to the work done.

COMPARATIVE COST OF STEAM AND ELECTRIC HAULAGES.

No. 1 *Haulage.*—This haulage is at present fitted with a coupled steam engine with steam cylinders 16″ diameter, by a 36″ stroke, and the drum is 6 ft. in diameter. The steam is conveyed directly down the shaft to the engine, which is close to the pit bottom. The general inclination of the seam is about 1 in 5, but there is a short distance slightly steeper than this where a roll has taken place. The average gross output for this haulage for the year was 156 tons per day, taking a month at 25 working days. The actual time worked by this haulage out of the 24 hours to raise this quantity, cannot of course be ascertained, but 16 hours actual working day may be taken as a good average.

There are four Lancashire boilers at this pit, supplying the steam power for all the machinery; the cost of two of these boilers has already been credited to the compressor as against the cost of working the dip pumps.

This leaves two Lancashire boilers for supplying steam for this haulage and for one coupled winding engine of the following dimensions: Steam cylinder 20″ diam., stroke

54″, and diam. of drum 12 ft., winding from a depth of 224 feet. This engine winds all the coal raised by the haulage to the surface, besides raising and lowering the miners, etc. The cost of running one of these boilers has been placed against the haulage engine and one against the winding engine. By so doing it is thought that a very close approximation to the actual cost is obtained.

The cost of running this haulage under steam is as follows :—

	Rs.
Cost of fuel per month, 187 tons, at Rs. 3 per ton ..	561
Cost of 3 Firemen per month, at Rs. 9	27
Depreciation on boilers at 20 years' life.. ..	33
Repairs, stores, etc.	20
Supplying dust and removing ashes	30
TOTAL ..	671
Cost of cylinder oil, packing, etc , not used in electric haulage	15
GRAND TOTAL PER MONTH ..	686

The cost of power for the electric haulage to take the place of above, works out at Rs. 31-6 per day on an output of 300 tons per day, assuming that the cost of power varies directly as the quantity raised, the distance being the same. The output on the steam haulage being 150 tons, it will be necessary to reduce the Rs. 31-6 to half. The cost of power for the electric haulage therefore is Rs. 15-11 per day. The cost per month of 25 days is Rs. 390 as against cost of steam haulage of Rs. 686, leaving a difference in favour of electric haulage of Rs. 296 per month.

No. 2 Haulage.—In considering the cost of this haulage it was impossible to get at the raisings. There are two haulages at work and the accounts are not kept separate.

To get at the cost of running the electric haulage an assumed output would require to be taken, which of course must be more or less a guess. However, the comparison made of No. 1 and 3 Haulages should convey a fair idea of the results to be expected from an electric-driven haulage as against steam.

No. 3 *Haulage.*—This haulage engine consists of a coupled engine with 14″ steam cylinder and 42″ stroke, and 6 feet drum, fitted near the pit bottom. Steam is supplied from boilers direct down the shaft. The average gross raising for this haulage for the year was 96 tons per day at 25 working days per month.

	Rs.
Cost of fuel per month, 111 tons, at Rs. 3 ..	333
Boiler khalasis 3, at Rs. 9	27
Repairs, stores, etc.	20
Depreciation on boiler	33
Supply of dust and removal of ashes	20
Cylinder oil and packing	15
TOTAL ..	488

The cost of running the electric haulage, designed for the above, works out at Rs. 22-8 per day on a gross raisings of 200 tons per day.

The above cost of steam haulage only represents an output of 96 tons per day, so if half the cost of running the electric haulage is again taken, the cost to do the above hauling electrically will be—

	Rs.
25 days at Rs. 11-4	281
Total for steam	448
Difference in favour of electric haulage	167

The cost of ropes and other stores have not been added as it is considered the cost of these will balance on each side.

To arrive at the probable total saving gained in putting the pumps and three haulages on electric power, it has been assumed that No. 2 electric haulage will be called upon to raise an average of 100 tons per day 25 days each month, and the cost of power for this work would be Rs. 139 per month. It will be noticed that this cost is much lower than either No. 1 or 3 haulages, due to the shorter haul, which is only half that of No. 1 haulage. The consumption and upkeep of one boiler has again been charged against this haulage, and the cost is as follows :—

	Rs.
Fuel 162 tons, at Rs. 3	486
Other charges	115
TOTAL ..	601
Cost of electric machine	139
Difference in favour of electric machine.. ..	462
The total saving per month amounts to—	
No. 1 Haulage..	296
No. 2 ,, ...	462
No. 3 ,, ...	167
TOTAL PER MONTH ..	925
Loss on electric pumping	46
TOTAL PER MONTH ..	879

and equal to 9% on capital outlay.

DISCUSSION.

In opening the discussion the President offered his opinion that the paper was a very practical one. Mr.

Miller admitted that electricity was valuable, but to what degree it was valuable the author did not seem to be quite sure. Apparently he wanted a little more convincing. In his view it was more adaptable and useful than steam or compressed air under nearly all circumstances. The author had given many estimates of cost for all methods of transmission of power, and that aspect could be suitably discussed at the meeting. He then called upon Mr. Mountain for some remarks.

Mr. W. C. Mountain said that he had not the honour of being a member of the Institute and, therefore, appreciated all the more the opportunity of making a few remarks on the paper. There were a good many points in it which required carefully looking into before really valuable figures could be ascertained. On the question of the pumps, he was afraid, he must take a contrary view to the author.*

Mr. E. H. Roberton then read the following paper:—

* Mr. Mountain's valuable contribution to the discussion will be published in full in the next part (Pt. 2) of the present volume.—*Ed.*

The Mining Department of the Civil Engineering College, Sibpur.

BY

E. H. Roberton, M.Sc., B.A., F.G.S., Professor of Mining Engineering at the C.E. College, Sibpur.

In view of the visit of the Institute of Mining and Geology of India to this College, it was suggested to the writer that a paper, descriptive of the recently-added Mining Department, and the course of training of the mining students, might prove of interest to the members of the Institute. Especially so, perhaps, since up to the present it is the only institution in India at which a mining diploma or degree may be obtained.

There is probably no profession that requires such a varied and all-round education in the allied sciences, as well as a very special knowledge of the subject itself, as mining; and for a mining engineer to reach the top of the tree, he must not only have a thorough practical and theoretical knowledge of mining, geology, and mineralogy, but should also possess a great deal more than a smattering of such sciences as mathematics, physics, chemistry, mechanical, civil, and electrical engineering, and in many cases, metallurgy. In drawing up a scheme for a mining course, it should be borne in mind that the dominant mining industry in the surrounding district, and the conditions governing it, should have the chief consideration. Especially in points of practical interest that affect these conditions, the mining school should aim at not only being abreast but a little in advance of the industry itself. This postulates a certain amount of elasticity in the syllabus with regard to the practical and laboratory work of the advanced students.

Course of Study.

The mining classes have been designed to afford theoretical training in the principles of mining generally, to prepare students for positions of responsibility in coal or metal mines, and in the case of students attending for instruction in coal-mining, to qualify them to appear for the examinations of mine managers, as required by the Indian Mines Act, VIII of 1901. A diploma in the principles of mining is granted to successful students, and has been recognised by the Government of India as remitting a portion of the time required to be spent in practical work by candidates for mine managers' certificates. A degree (Bachelor of Engineering in Mining) course, in connection with the University of Calcutta, is also to be commenced, and will, doubtless, receive similar recognition.

The students attending the Mining Department may be of the following descriptions :—

1. *Special students.*—Persons resident in Bengal, who have been employed upon mines, admitted under the conditions :—

(*a*) that they have completed at least two years' practical work upon a mine ; and

(*b*) that they have passed (*i*) the B. Final Examination ; (*ii*) the Matriculation or Entrance Examination of any Indian University ; or (*iii*) any test equivalent to the Middle School Examination of the Code for European schools.

2. *Regular students* (*diploma*).—Qualified for admission by passing the Sub-Overseer Examination of the C.E.

College, or an equivalent test of some other college. Age-limit on admission, 17 to 19.

3. *Regular students (degree)*.—Qualified for admission by passing (*i*) the F.A. Examination of the Calcutta University, or a similar "recognised" examination. Age-limit, 21 years; or (*ii*) the B.A. Examination in the B. Course in Physics and Chemistry of the Calcutta University. Age-limit, 23 years.

Of the above descriptions of students Nos. 1 and 2 are attached to the "Apprentice," and No. 3 to the "Engineer" courses at the College.

Arrangements are in progress for the drafting of students, both "regular" and "special," from other provinces to the Mining Department of the Sibpur Engineering College.

Scholarships.

For regular students.—Two scholarships of Rs. 12 monthly, and three of Rs. 6, are provided. These are awarded on the results of the Sub-Overseer Examination by the Director of Public Instruction, on the recommendation of the Principal. Students trained at the C.E. College or any affiliated technical school in Bengal are eligible.

For special students.—Two scholarships of Rs. 150 monthly for European candidates, and two of Rs. 50 monthly for Indian candidates, each tenable for two years. These will be awarded annually by the Director of Public Instruction, on the recommendation of the Mining Advisory Board.

The full course for diploma students at the College extends over four years, the first two of which are taken up in passing the "Sub-Overseer" Examination. An abridged account of the work done is given here. A detailed account of each subject would be too long to give, and is to be found in the College Calendar. A table of the hours per week devoted to each is given on p. 58.

First Year :—

- Mathematics.
- Practical Physics and Chemistry.
- Engineering.
- Drawing.
- Surveying, class and field-work.
- Carpenter's shop.

Second Year :—

- Mathematics.
- Practical Physics and Chemistry.
- Engineering.
- Estimating.
- Drawing.
- Surveying, class and field-work.
- Carpenter's and Blacksmith's shops.

Third Year :—

- Mathematics.
- Physics and Chemistry.
- Drawing.
- Mining and Mine Surveying (see p. 56).
- Moulder's and Pattern-maker's shops.

Fourth Year :—

- Mathematics.
- Physics and Chemistry.
- Applied Mechanics.
- Drawing.
- Mining and Mine Surveying.
- Fitter's shop.

Candidates for the degree of B.E. in Mining specialise in mining during the last two years of the B.E. course, as laid down in the Calcutta University Calendar. The following are the subjects in which candidates are examined at the various stages of the course, and the marks apportioned to each subject :—

FIRST ENGINEERING EXAMINATION.

				Marks.
I. Mathematics	Computations and Mensuration		..	400
	Algebra, Trigonometry, and Analytical Geometry		..	400
	Statics and Dynamics		..	400
	Differential and Integral Calculus		..	400
II. Geodesy ..	Practical		..	300
	Question Paper		..	200
III. Materials of Construction			..	400
IV. Natural and Experimental Science.	A. Chemistry	Question Paper	..	200
		Practical	..	200
	B. Physics	Light, Heat, Electricity and Magnetism	..	200
		Applied Physics	..	200
		Practical	..	200
V. Drawing ..	Practical		..	300
	Question Paper		..	200
		GRAND TOTAL	..	4,000

The pass-marks are one-third in each subject, and half of the aggregate for a Second Class, and two-thirds for a First Class.

INTERMEDIATE EXAMINATION IN ENGINEERING.

			Marks.
I. Mathematics	Computations and Mensuration	..	400
	Statics, Dynamics, and Applied Mechanics	..	500
	Analytical Geometry and the Calculus	..	300
II. Science ..	Chemistry	..	250
	Practical Chemistry	..	250
	Physics	..	250
	Practical Physics	..	250
	Carried over	..	2,220

			Marks.
		Brought forward	2,220
III.	Engineering	Materials of Construction	400
		Details of Construction	400
		Estimating	200
IV.	Surveying	Question Paper	200
		Practical	300
V.	Drawing	Question Paper	200
		Practical	300
		GRAND TOTAL	4,200

To pass, one-third marks in each group is required, and half of the aggregate.

B.E. EXAMINATION (MINING ENGINEERING).

			Marks.
I.	Mathematics	Pure Mathematics	200
		Mixed Mathematics	300
II.	Science	Geology and Mineralogy	200
		Metallurgy, etc.	200
		Applied Physics	200
		Practical Engineering Physics	400
III.	Engineering	Applied Mechanics and Hydraulics	400
		Engines and Machinery, Part I	400
		Electrical Engineering, Part I	400
		Mining, Part I	400
		Mining, Part II	400
IV.	Drawing and Design.	Theoretical Paper	200
		Attested Drawings and Designs for Works and Buildings	700
		GRAND TOTAL	4,400

The pass-marks are one-third in each group of subjects, and half of the aggregate for a Second Class. For a First Class two-thirds of the aggregate are required.

The specimen Routine Table given below shows the method in which the students' time is divided during the week. It is subject to slight periodical alterations, to suit the needs of the College during the different seasons of the year. From the new year till the middle of February the mining students are in camp in a mining district, studying practical mining and geology, and making mine surveys. The students attend this in their third and fourth years, having previously gone through the first and second year practical surveying course, also held in the cold weather.

SPECIMEN ROUTINE FOR MINING STUDENTS.

From 4th November, 1908.

Day.	Year.	8 to 9.	9 to 11.	12-30 to 2.	2 to 3.	3 to 4.
Monday ..	1st year.	Carpenter's Shop.		Engineering.	Drawing.	Mathematics.
	2nd ,,	Carpenter's and Blacksmith's Shops.		Mathematics.	Drawing.	Drawing.
	3rd ,,	Moulding and Pattern-making.		Drawing.	Mathematics.	Chemistry.
	4th ,,	Fitter's Shop.		Drawing.	Chemistry.	Applied Mechanics.
Tuesday ..	1st ,,	Carpenter's Shop.		Mathematics.	Drawing.	
	2nd ,,	Carpenter's and Blacksmith's Shops.		Engineering.	Practical Chemistry.	
	3rd ,,	*Geology.*	*Mining Laboratory.*	Drawing.	....	Mathematics.
	4th ,,	Fitter's Shop.		Drawing.	Mathematics.	*Mining Engineering.*
Wednesday ..	1st ,,	Carpenter's Shop.		Prac. Chemistry (2 hours).	Mathematics.	Engineering.
	2nd ,,	Carpenter's and Blacksmith's Shops.		Mathematics.	Drawing.	
	3rd ,,	Moulding and Pattern-making.		Drawing.	*Mining Engineering.*	Chemistry.
	4th ,,	*Coal Mining.*	*Mining Laboratory.*	Drawing.	Chemistry.	Mathematics.
Thursday ..	1st ,,	Carpenter's Shop.		Mathematics.	Drawing.	
	2nd ,,	Carpenter's and Blacksmith's Shops.		Engineering.	Drawing.	
	3rd ,,	Moulding and Pattern-making.		Drawing.	*Mining Engineering.*	Physics.
	4th ,,	*Mineralogy.*	*Mining Laboratory.*	Drawing.	Physics.	Mathematics.
Friday ..	1st ,,	Carpenter's Shop.		Mathematics.	Drawing.	
	2nd ,,	Carpenter's and Blacksmith's Shops.		Prac. Physics (2 hours).	Drawing.	
	3rd ,,	*Coal Mining.*	*Mining Laboratory.*	Drawing.	....	Physics.
	4th ,,	Fitter's Shop.		Drawing.	Physics.	*Metal Mining.*
Saturday ..		8 to 10.		12-30 to 1-30.	1-30 to 2-30.	
	1st ,,	Carpenter's Shop.		Practical Physics.		
	2nd ,,	Carpenter's and Blacksmith's Shops.		Mathematics.	Engineering.	
	3rd ,,	Moulding and Pattern-making.		*Metal Mining.*	Mathematics.	
	4th ,,	Fitter's Shop.		....	Applied Mechanics.	

Mining subjects are shown in italics.

The syllabus of the mining lectures is given below, Course I being taken in the students' third year (*i.e.*, after passing the Sub-Overseer Examination), and Course II in the fourth year.

DETAILED SYLLABUS OF MINING LECTURES.

Course I.

Geology applied to Mining.—(One lecture per week.)

Stratified and unstratified rocks. Faults, foldings, etc. Work done by rivers and glaciers. Rock-forming minerals. Introduction to study of fossils. Principal rock-formations and descriptive outline of corresponding fossils. Special reference to the geology of India. Mountain and river systems. Metamorphic rocks. Dravidian and Aryan groups. Coal-bearing formations. Laterite formation.

Geological maps and sections. Methods employed in their construction. Field geology.

Mining Engineering.—(Two lectures per week.)

Boring by hand and power machines. Lining boreholes. Speeds and costs of various methods of boring compared.

Sinking through alluvial ground. Bogey, dumping-chain, folding-doors. Shaft-walling. Sinking and walling simultaneously. Tubbing a shaft. Sinking through sands and gravel and watery strata. Piling method. Iron drum and Kind-Chaudron methods. Freezing processes. Triger's process.

Mechanical haulage. Jig bank. Direct haulage. Main and tail rope. Endless rope. Modes of application of power. Size of engine required for given work. Tensioning the rope.

Hoisting. Wood, steel, and rope guides. Safety cages and appliances. Koepe and Whiting systems. Rope capping and cage couplings. Winding ropes. Safety factor.

Mining legislation with reference to shafts, hauling, winding, timbering, shot-firing, inspection of working-places, and mine plans.

Coal Mining.—(One lecture per week.)

Methods of working coal. Development of bord-and-pillar working. Main distinctions between longwall and bord-and-pillar working. Thrust and creep. Shaft pillars. Haulage roads and their protection. "Whole" and "broken" working. Timbering. General remarks on removal of pillars. Timber withdrawal. Longwall working. Timbering and packwalls. Thick coal working. South Staffordshire method. Indian and American methods. Special instances. Single and double stall working. Steep seam workings. Rearer workings of North Staffordshire.

Shot-firing. Coal-cutting by machinery. Different types of machines and their uses.

Working under the sea or large bodies of water. Surface subsidence.

Coal-mine plans and sections. Connecting surface and underground surveys.

Metal Mining.—(One lecture per week.)

Description of veins, pockets, shoots, chimneys. Lenticular masses.

Prospecting for minerals. Alluvial mining and open working. Ore beds and deep leads. Dredging for gold. Overhand and underhand stoping. Working a thick mineral vein. Timbering of metal mines. Square-set timbering. Shaft-timbering.

Hand and power drilling. Pneumatic and electric drills. Blasting. Metal mine plans.

Course II.

Descriptive Mineralogy.—(One lecture per week.)

Important minerals and ores. Fuels and allied materials. Methods of determination of minerals. External characteristics. Specific gravity. Forms of minerals. Systems of crystals and examples. Blowpipe assay. Scale of fusibility. Tests on borax, microcosmic salt and charcoal. Tests with nitrate of cobalt.

Special reference to ores of iron, antimony, baryta, zinc, tin, mercury, copper, lead, manganese, gold, and silver.

Mining Engineering.—(One lecture per week.)

Drainage of mines. Adit levels. Water-buckets. Lift and force pumps. Surface arrangements for draining a sinking pit. Cornish and Hathorne-Davy pumps. Direct-acting steam pumps. Pulsometer. Centrifugal pumps. Hydraulic pumps. Auxiliary pumps for feeding up to the main pump.

Approaching old workings. Dams.

Ventilation. Stoppings, doors, regulators, air-crossings. Practical work in plan ventilation. Dumb drifts. Capell, Waddle, and Guibal fans. General reference to types of fans. Water-gauge and anemometer. Treatment of gob-fires.

Power-application in a mine. Relative merits of steam, water, compressed air, electricity, and oil, as sources of applied power.

Indian Mines Acts, and legislation germane to mining.

Coal Mining.—(One lecture per week.)

Description of gases found in mines. Fire-damp. Colliery explosions. Spraying apparatus. Principles and construction of safety-lamps. Types of safety-lamps.

"Caps" on safety-lamp flame. Instruments for detecting fire-damp—opal spectacles, Liveing's and Ansell's indicators, alcohol lamp, hydrogen lamp, Beard-Mackie lamp. Treatment of persons overcome by foul air.

Surface arrangements at a colliery. How they are made automatic as far as possible. Sorting and screening. Tipplers, creepers. Coal-washing,—types of machines. Coking,—types of ovens. Recovery of bye-products.

Metal Mining.—(One lecture per week.)

Ore-dressing. Concentration by means of water. Blake crusher. Dodge crusher. Gyratory crushers. Huntington mill. Stamp batteries. Materials required for running a stamp battery. Classification of pulverisers. Arrastra. Amalgamating pans. Jigs, and jig products. Magnetic separation. Roasting for magnetism. Pneumatic separation. Less important methods of concentration.

Fine sand and slime concentrators. Vanners, pumping or jerking tables. Prospector's cradle. Treatment of refractory ores, sands, and slimes. Cyanide and chlorination treatment.

PRACTICAL MINING AND MINE SURVEYING.

Students are required to spend six weeks in camp, each year of the course, in a mining district, of which about three weeks are devoted to the surveying of an actual working mine, the remainder of the time being spent in visiting and inspecting the workings and equipment of mines in the vicinity. The surveying consists of a plan of the mine, with surface connections, and one or more sections along a haulage road. The plan and sections, and the notes on mine equipment made during camp, are to form the basis of the "Attested drawings and designs" required from the "degree" students.

ATTESTED DRAWINGS AND DESIGNS.

(1) Plan of mine workings, based on survey done in camp, suited for an output of 1,500 tons per day, showing surface buildings, railways, waterways, etc., and pillars left for their protection; showing also doors, regulators, stoppings, etc., for ventilation purposes;—on a scale not smaller than 100 feet to the inch.

(2) Section of a haulage road, showing new formation level for purposes of installing mechanical haulage.

(3) Section of upcast shaft, showing fan-drift, fan-house, and fan.

(4) Vertical section of downcast shaft, showing pumps, steam-pipes, and cages.

(5) Plan of downcast shaft.

(6) General plan of surface arrangements, showing position of tipplers, screens, coke-ovens, boilers, engines, etc.

(7) Section of portion of shaft, to show walling curb and brick work and wedging curb with tubbing.

Other examples may be set from time to time.

Some comparison of the hours of work per week and the subjects taken by students who have entered upon a mining diploma course at Sibpur and various other colleges, British and American, should prove of interest. In some of the colleges quoted in the following tables a subject is occasionally taken up for one-half of the session and dropped for the other half. In such cases the hours per week are averaged over the whole session, for the sake of uniformity.

CIVIL ENGINEERING COLLEGE, SIBPUR.

First year.	Hours per week.	Second year.	Hours per week.
Mathematics	5	Mathematics	4
Physics	2	Physics	2
Chemistry	2	Chemistry	2
Drawing	7	Drawing	6
Engineering	$2\frac{1}{2}$	Engineering	4
Workshops	17	Workshops	17
Total ..	$35\frac{1}{2}$	Total ..	35

Third year.	Hours per week.	Fourth year.	Hours per week.
Mathematics	3	Mathematics	3
Physics	2	Physics	2
Chemistry	2	Chemistry	2
Drawing	$7\frac{1}{2}$	Applied Mechanics ..	2
Geology	1	Drawing	$7\frac{1}{2}$
Mining	4	Mineralogy	1
Mining Laboratory ..	4	Mining	3
Workshops	11	Mining Laboratory ..	4
		Workshops	11
Total ..	$34\frac{1}{2}$	Total ..	$35\frac{1}{2}$

Cold Weather Mining School.—Six weeks spent in each of the third and fourth years in camp in a mining district, for the purpose of mine-surveying and the study of practical mining.

McGILL COLLEGE, MONTREAL.

First year.	Hours per week.	Second year.	Hours per week.
Mathematics	10	Mathematics	6
English	2	Mapping	3
Geometrical Drawing and Lettering	4	Surveying	2
		Chemistry	7
Physics	8	Physics	5
Geometry	3	Geometry	3
Freehand Drawing ..	3	Drawing	3
Workshops	7	Workshops	4
Total ..	37	Total ..	33

Third year.	Hours per week.	Fourth year.	Hours per week.
Mathematics	2	Geology	2½
Geology	3	Mineralogy	1
Do. Excursion ..	4	Metallurgy	3½
Mineralogy	5	Hydraulics	2
Metallurgy and Assaying	2½	Laboratory Work ..	11½
Transport	1	Mining	5
Structures	1	Drawing and Design ..	1
Machine Design and Drawing	5		
Graphical Statics ..	1		
Chemistry	3½		
Ore-dressing	2		
Mining	1		
Total ..	31	Total ..	26½

Summer School in Mining.—Six weeks, at the end of the third year course. One week devoted to geology, and the rest to practical mining, visits to metallurgical works, etc.

COLUMBIA UNIVERSITY, NEW YORK.

First year.	Hours per week.	Second year.	Hours per week.
Chemistry	6	Chemistry	12
Civil Engineering ..	1	Civil Engineering ..	1½
Mathematics	5	Electrical Do.	1½
Mechanical Engineering ..	2	Geology	3
Drawing	5	Mathematics	3
Mineralogy	5	Mechanical Engineering	2
Physics	3	Drawing	5
		Mechanics	3
Total ..	27	Total ..	31

Third year.	Hours per week.	Fourth year	Hours per week.
Chemistry (one term) ..	12	Civil Engineering ..	1½
Civil Engineering ..	3	Geology	7½
Electrical Do.	1	Mechanical Engineering	1
Geology	3	Mechanics	1
Mechanics	1½	Metallurgy	1½
Metallurgy	2	Mining (lectures) ..	5½
Mining (lectures) ..	3½	Mining (laboratory) ..	after-noons for 3 weeks.
Mineralogy	1		
Total ..	27	Total (excl. lab.) ..	18

Summer School.—Six weeks, at end of third year. One week devoted to geology, and the rest to inspection of mines, mine-surveys, etc.

A short special course is given in Mechanical Engineering in the third year.

A thesis on some mining subject is required at the end of the course.

LEHIGH UNIVERSITY, PA.

First year.	Hours per week.	Second year.	Hours per week.
Mathematics	3½	Mathematics	5
Chemistry	3½	Physics	4
Physics	1½	Mineralogy and Assaying	5
German and French ..	3	Crystallography ..	1
English	2½	Metallurgy	1½
Drawing	3	English	2
Hygiene	1	Public-speaking ..	½
Gymnasium	2	Surveying (4 weeks)* ..	..
Surveying (4 weeks).* ..	..		
Total (excl. surveying) ..	20	Total (excl. surveying) ..	19

Third year.	Hours per week.	Fourth year.	Hours per week.
Geology	4	Graphic Statics ..	1
Ore-dressing	1½	Geology	2½
Mechanial Engineering ..	4	Electrotechnology ..	2½
Assaying	2	Metallurgy	2½
Metallurgy	2½	Engineering Laboratory	1
Mining	2½	Mechanical Engineering	1
Hydraulics	1½	Mining	5
Biology	1½	Thesis	1½
Economics..	1		
Mine-surveying, Mine Railroads (4 weeks)*			
Total (excl. surveying) ..	20½	Total ..	17

* *Summer School.*

COLORADO SCHOOL OF MINES.

First year.	Hours per week.	Second year.	Hours per week.
Mathematics	8	Mathematics	5
General Chemistry ..	5	Physics	7
Qualitative Analysis ..	7½	Technical Chemistry ..	2
Drawing	9½	Quantitative Analysis..	10
Surveying	1	Mineralogy	8
Geology	1½	Mine-surveying ..	2
Geological Field-work, four trips on Saturdays.	..		
Total (excl. Field-work) ..	32½	Total ..	34

Third year.	Hours per week.	Fourth year.	Hours per week.
Advanced Geology ..	4	Geology	3
Metallurgy	9	Metallurgy	3
Mechanics	6½	Ore-dressing	3
Testing Laboratory ..	1½	Engineering	6½
Machine Design	8	Electrical Engineering	2½
Mining	3	Hydraulic Do. ..	2½
Geological Field-work, four trips.	..	Mining	11½
Mining Excursions, four trips.	..	Mining, Ore-dressing, and Metallurgical trips—ten trips.	..
Total (excl. Field-work) ..	32	Total ..	32

Summer School { First year, 4 weeks' surveying.
Second year, 4 weeks' mine-surveying.

ROYAL SCHOOL OF MINES, LONDON.

First year.	Hours per week.	Second year.	Hours per week.	Third year.	Hours per week.
Mathematics	4	Graphics	3	*First term*—	
Chemistry	3	Geology and Mineralogy	2½	Metallurgy and Assaying	21—23
Do. Laboratory ..	9	Do. Laboratory ..	7½	*Second term*—	
Physics	3	Mechanics	2½	Mine-surveying*	21—23
Do. Laboratory ..	9	Do. Laboratory .	5	Mining, Surveying, and Metallurgy	8—10
Drawing	3	Drawing	3		
		Electricity	1		
		Do. Laboratory..	3		
Total ..	31	Total ..	27½	Total ..	31

* Including six weeks' work at mines in addition to field-work in or near London.

GLASGOW UNIVERSITY.

First year.	Hours per week.	Second year.	Hours per week.	Third year.	Hours per week.
Mathematics	5	Applied Mechanics, and Materials of Construction	5	Electrical Engineering ..	3
Natural Philosophy ..	5			Metallurgy	2
Chemistry	5	Surveying	3	Do. Laboratory ..	6
Do. Laboratory ..	6	Mechanical Engineering	3	Engineering Laboratory ..	6
Mining	2	Drawing	6	Mining	1
		Geology and Mineralogy	4		
		Mining	2		
Total ..	23	Total ..	23	Total ..	18

BIRMINGHAM UNIVERSITY.

First year.	Hours per week.	Second year.	Hours per week.
Mathematics	4	Chemistry	4
Physics	3	Do. Laboratory ..	6
Do. Laboratary ..	2	Geology	6
Geology	6	Drawing	3
Mining	2	Mining	1
Surveying	2	Do. Laboratory ..	3
		Surveying	2
Total ..	19	Total ..	25

Summer School.—Four weeks in each year spent in a mining district.

ARMSTRONG COLLEGE (UNIVERSITY OF DURHAM).

First year.	Hours per week.	Second year.	Hours per week.
Mathematics	5	Engineering	4
Physics	3	Do. Laboratory	6
Do. Laboratory ..	6	Practical Geometry ..	3
Chemistry	3	Mineralogy	1
Do. Laboratory ..	6	Mineral Deposits ..	1
Geology	2	Ore-dressing	1
Geological Surveying ..	6	Mining	2
		Surveying	7
Total ..	31	Total ..	25

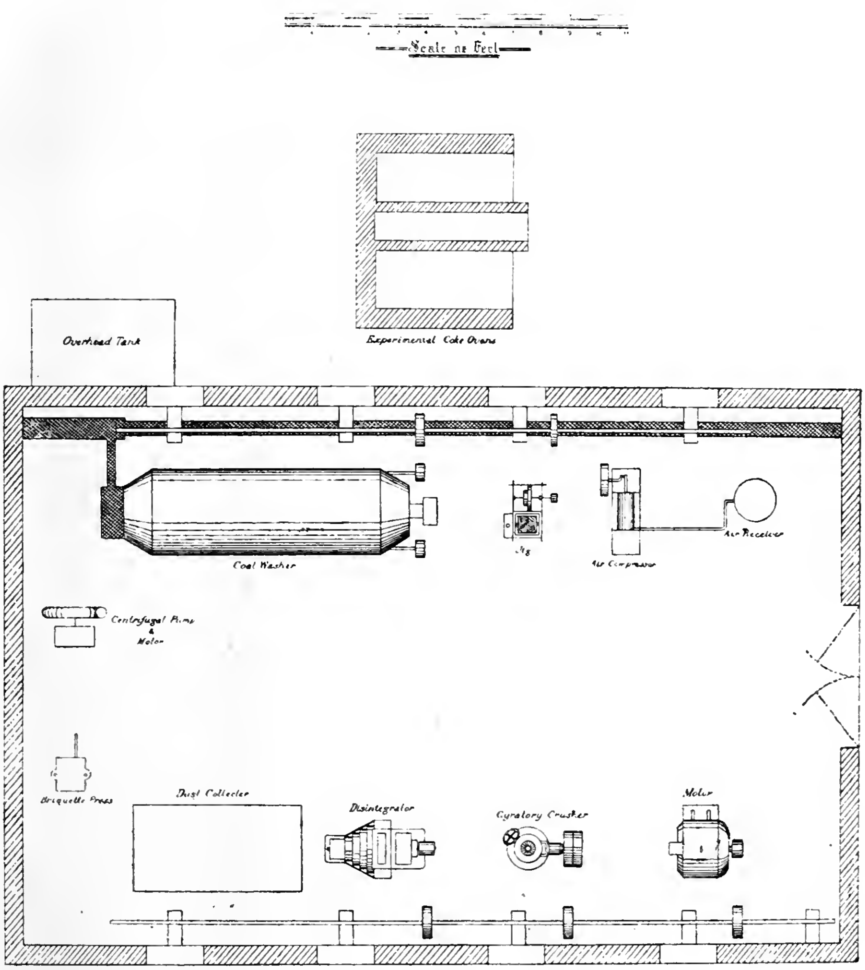
Mining Laboratory and Practical Work.

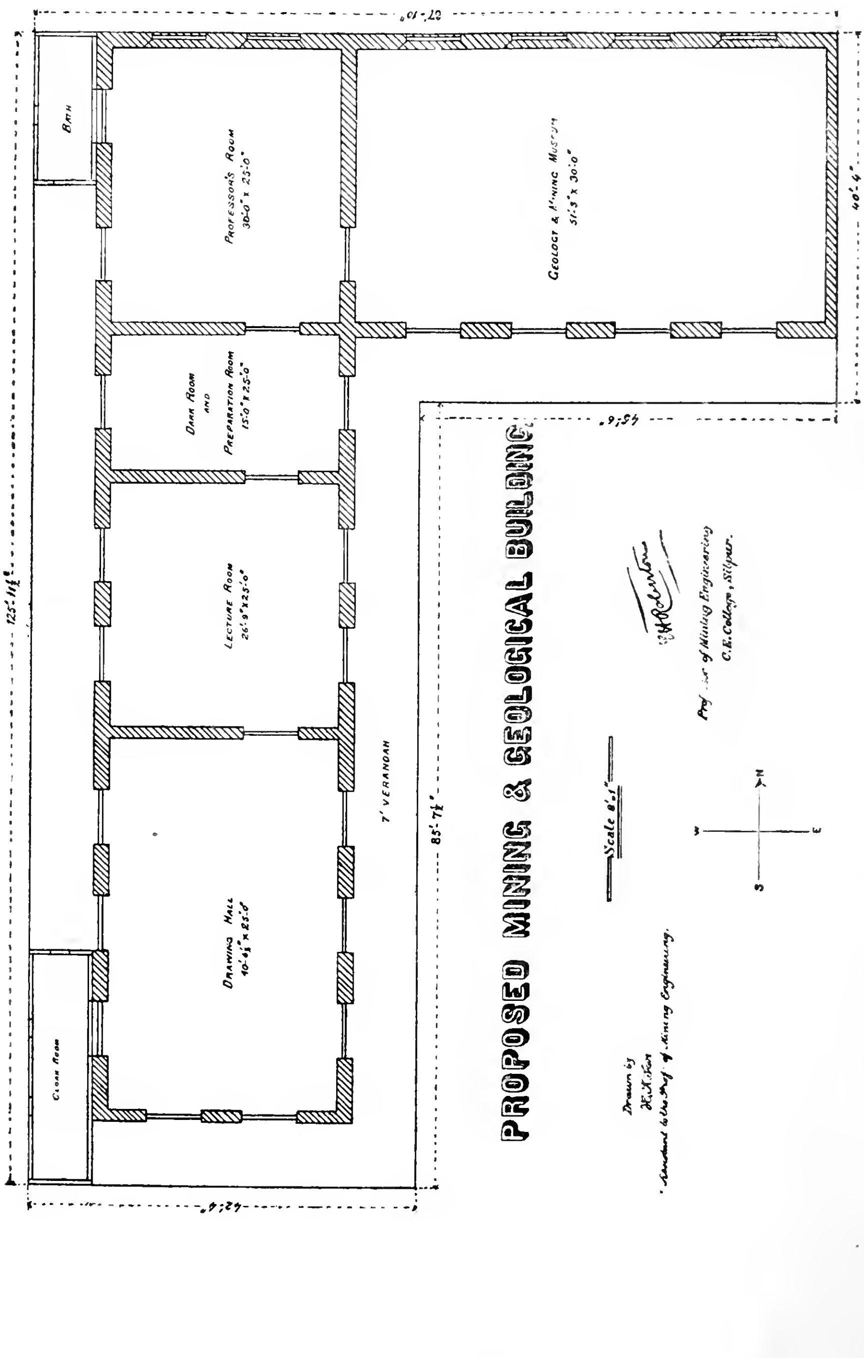
In designing and equipping the mining laboratory special regard is being paid to the conditions of the chief mining industry in Bengal, coal-mining, to which the College is most nearly situated, and into which the majority of passed students will probably be drafted.

Practice and research may well be carried on on the lines of washing, briquetting, coking, and the recovery of by-products. Again, as the coalfields are only partially opened up, prospecting work is of great importance, and many inquiries have been received at the College for passed students with a knowledge of boring. For this reason one of the first pieces of apparatus with which the laboratory has been equipped is a boring outfit. Again, the recent outbreak of fire in an Indian colliery has suggested the equipment of the laboratory with a complete set of rescue apparatus, which is being ordered out from Home this year. Additions will be made as other suggestions or ideas occur.

A diagram showing the mining laboratory and its equipment is given (see figure, p. 67). The motor is a 10 H.P. c.c. motor, enclosed type, such as would be used underground. Two poles are shunt-, and two compound-wound. A Wooliscroft liquid starting switch, with automatic no-voltage and overload release, is provided. The machines at present installed, or shortly to be installed, consist of a gyratory crusher, a multiple type disintegrator with a dust collector attached, a jig (Hartz type), a Blackett coal-washer, and a briquette press. The water for the jig and coal-washer gravitates from an overhead tank holding 180 gallons, and kept supplied by a centrifugal pump worked by a 3-phase motor of 1 H.P. Other apparatus are a set of boring tools with which a certain amount of work has already been done (alluvial) by the students; a small air-

SIBPUR COLLEGE
COAL MINING LABORATORY




PROPOSED MINING & GEOLOGICAL BUILDING
Bath
Professor's Room 30'-0" x 25'-0"
Geology & Mining Museum 51'-5" x 30'-0"
Dark Room and Preparation Room 15'-0" x 25'-0"
Lecture Room 26'-9" x 25'-0"
Drawing Hall
Cloak Room
7' Verandah
125'-11½"
85'-7½"
40'-4"
Scale
C.E. College, Sibpur.

compressing plant, and a percussive-power drill ; and to be added later, some experimental coke-ovens, in which the difference in the coke produced from coal ground to different degrees of fineness, and rammed to varying degrees of hardness, may be observed, and also the collection of bye-products demonstrated. The students of the third year will be entrusted with the mechanical portion of the work, *e.g.*, crushing, disintegrating, and washing ; and the coking, by-product collection, etc., will be in the hands of the fourth year students. It is hoped that when the plant is installed, colliery managers will help by sending occasionally some coal in bulk, a few tons say at a time, for testing, thereby serving the purpose of giving the students work with a distinct object in view, and also perhaps themselves learning something about the probable behaviour of their coal under the conditions tested for.

The President said a great many men would probably be educated at Sibpur and fill positions in the collieries in future. A very good work was being done at the College, and they hoped in the future to see it producing qualified men by the dozen.

Mr. B. Heaton, Principal of the College, said he had not had the opportunity of seeing this paper and putting a few remarks together, but he hoped to do so, and give them something in writing. He wanted them to remember when they came to visit the College that the College authorities had not been able to get the mining department they would have liked. Unfortunately Sibpur College is not situated in a healthy position, and a proposal for removal had been under consideration for six years. It was still undecided, and in that six years it has, of course, been impossible to get any money spent on the College. They hoped to get the matter settled by the end of the year, and then they would know whether they had to develop at Sibpur or elsewhere. At Sibpur they had not much accommodation for the mining department, but they hoped to improve it before long. They were not particularly proud of their present position, and if the members would do anything to help on the work of the department, they would be very grateful.

Mr. L. L. Fermor then gave a brief account of the Nagpur Exhibition, promising to supplement it with a fuller desciption in print; this latter will be published in the next issue of these "Transactions."

THE RANIGANJ MAP.

Mr. R. R. Simpson, Secretary of the Raniganj Map Committee, said they had not issued any report this year as there had not been a great deal to report upon. The work was proceeding, although not at the rate they would like to see it proceed. He would impress upon the members the importance of the work and the desirability of getting as much of it done as possible. They had asked the members of the Committee to recommend a suitable man as Surveyor, but as yet they had not got one.

WATER IN BIKANIR.

In the absence of the author, the paper on "The Waters of Bikanir," by Mr. W. H. Pickering, was taken as read. The paper will appear in the next part of the "Transactions."

GENERAL DISCUSSION.

Mr. W. Miller said that since the last meeting he had visited the Nursamooda Colliery and seen the longwall working which has been carried on very successfully indeed. The longwall face is of course a short one, and it does not give a fair chance yet to see its possibilities, but it is being gradually extended. He was also very pleased to see there a coal-cutting machine—a rotary one—which cuts the coal in a 5 ft. seam very successfully. At that colliery, too, they have got a very good compressed air plant, and he would advise all to go and see it. Mr. Howarth has had, and still has, hard work there—he has been working practically night and day—and the result is a very great credit to him.

Questions were then asked if it was not possible to have a small apparatus on the coalfield to carry out experiments with the dust. They would want some money, but they had sufficient funds in hand to meet the expenditure.

Mr. W. Howarth subsequently wrote that he thought that the results of home experiments would probably be more useful than any which could be obtained at present in India. He advocated some research on the question of cholera as affecting the mining industry.

Mr. Simpson, on Mr. Pickering's paper "Fighting a Colliery Fire," said he thought a committee might be appointed to report on the possibility or advisibility of putting down a rescue station.

The President said those matters might very well be brought before the Council, together with the question of establishing a lending library.

Mr. Wilson moved, and Mr. Heaton seconded, a vote of thanks to the President for his interesting address, and the meeting closed with a similar vote to the Asiatic Society for lending their rooms.

The Annual Dinner.

The Annual Dinner of the Institute was held at the Headquarters of the Presidency Volunteers, the President, Mr. H. G. Graves, taking the chair. The members present included Messrs. G. F. Adams, F. J. Agabeg, R. P. Ashton, A. G. Bennertz, D. Blair, R. J. Browne, P. Brühl, W. L. Carey, W. R. Criper, T. Chrystle, G. Dixon, L. L. Fermor, B. S. Field, A. Finlayson, H. G. Fleury, W. Forster, A. Gillespie, H. G. Graves, G. H. Greenwell, W. T. Griffiths, H. H. Hayden, B. Heaton, S. Heslop, Sir Thomas Holland, W. Howarth, Major F. C. Hughes, W. Hullock, L. A. Jacobs, J. W. Jervis, W. E. Lawrie, G. C. Leach, R. H. Longbotham, C. H. McCale, A. Mackay, J. Mackintosh, G. S. Martin, J. A. Miller, G. Miller, W. Miller, A. J. Mitchell, G. K. Mitchell, R. Mitchell, T. Morrison, T. C. Murray, C. Nairne, J. W. Nierses, W. H. Phillips, T. C. Piggford, W. J. Rees, H. H. Reynolds, E. H. Roberton, A. T. Rose, A. Russell, A. V. Sam, C. Schulten, G. F. Scott, S. H. Seddon, G. Shearer, F. M. Short, R. R. Simpson, E. Sommerfeldt, J. Thomas, A. S. Thomson, H. T. Thomson, G. H. Tipper, J. J. Turnbull, H. C. Veasey, T. Walsh, J. White, H. L. Wilkinson, J. R. R. Wilson.

Among the guests were Messrs. Archdale, Baldrey, Benson, Bert, Black, Bree, Carapiet, A. J. W. Christie, W. A. K. Christie, Cotes, A. G. Elliott, W T.Elliott, Exley, Forbes, Gibson, Gordon, M. M. S. Gubbay, I.C.S., Hind, Hockley, Jardine, Kean, Phil. Knight, W. A. Lee, H. V. Low, H. H. Macleod, B. E. Mac Murtrie, W. C. Mountain, G. Rainey, I.C.S., Hon. Mr. Justice T. W. Richardson, Messrs. B. Robertson, I.C.S., L. W. Smith, J. E. Snelus, F. H.

Stewart, Major Thomson, Messrs. A. Topping, C. Wansburg, J. Wheelan, E. A. Whyte.

After dinner the President gave the toasts of "The King," and "The Viceroy, and "the land we live in," which were heartily honoured.

The President then proposed "The Mining and Mineral Industries." He said that in drinking that toast they would be drinking to themselves. During the past two years those industries had prospered very greatly, and they hoped and expected they would prosper still more greatly in the coming years. Their Institute had been doing much, and would do more, for the minèral industries of the country. He mentioned the effect of capital on the prices of mining shares, but said the ups and downs of those shares gave no idea of the real position of the industries concerned. Coupled with that toast they had the name of one of their members who was going away. He referred to Sir Thomas Holland, K.C.I.E, D.Sc., F.R.S., A.R.C.S., F.G.S., who was going home to take the place of Professor Boyd Hawkins at Manchester University. Sir Thomas came out to India in 1890, and in 1903 was appointed Director of the Geological Survey. They knew the work he had done for the industries of this country, and they knew that at Manchester University he would do a great work for science in the world generally.

In reply, Sir Thomas Holland said :—

Mr. President and Gentlemen :—

I have to thank you very much for the generous enthusiasm with which you have endorsed the President's remarks concerning my connection with the mineral industries of India. Nevertheless, I protest that some more suitable person might have been chosen to respond to this toast ; the relation of the Geological Survey to the mineral industries of the country is no more than that usually existing between the average parson's sermon and his text—we merely provide a commentary on the work actually done by you real workers.

When Mr. Graves forced me to undertake this duty I objected that, having had to perform in some capacity or other at every function of this kind since the foundation of the Institute, it is desirable, if only for the sake of variety, that I should be allowed to enjoy my last dinner with you as a peaceful listener. I am now puzzled to know whether your enthusiastic reception is evidence of generous toleration, or simply joy over the fact that at these gatherings you will see my face no more.

It has been suggested that I should take this opportunity of reviewing the progress of mineral development during the six years that I have had charge of the Geological Survey. There are two good reasons for putting aside this suggestion : firstly, it would be dangerous to fill you with indigestible statistics when you are enjoying the palatable nourishment provided by our good friend Federico Peliti ; secondly, such a proceeding would be taking my position too seriously : I am but—

"A chiel among ye takin' notes."

You will find the facts and some of the lessons regarding the progress of Indian mineral development set forth in the "Records of the Geological Survey," and I will do no more now than repeat what I urged on you in the second of my two Presidential Addresses regarding the dangerous simplicity of our mineral industries in this country, and their consequent condition of unstable equilibrium : so long as you raise minerals only, or even mainly, for export in the raw state, you are liable to suffer from fluctuations of the foreign market to a degree accentuated by the ratio between the cost of transport and the selling prices. Industries in this condition are not in a state of ebb-and-flow merely, but are marked by alternating periods of demoralizing success and almost complete extinction, like the vegetation of a desert region, where the dry period is a drought and the rainy season one of floods. The recent history of manganese-ore mining illustrates this point in a way that is appreciated by some of you. With manganese at a shilling a unit the profits you can make in a year may be, in many mines, greater even than the capital laid out in your simple open quarries; with a drop to eight-pence, those of you with properties far from the coast are compelled to discharge your coolies and to sit in fear that before another rise occurs you will be in danger of forfeiting your leases through non-fulfilment of the condition requiring continuous working. These violent fluctuations are unhealthy for those of you who are tied to the manganese industry; they are disastrous to the labour market, and distracting to the Government responsible for the well-being and development of public works in the mining districts. I am glad, however, to see that a steadying influence is being developed by the action of some large steel and iron makers in securing their own properties in India. They are able to obtain the ore at reasonable rates in times of boom, and they keep the industry alive during times of depression. This move is as good for the buyer as it is for the country of production, and it is welcome as the best substitute at present obtainable for the local manufacture of ferro-manganese. Among those who have taken part in this new phase of the manganese industry, one might mention the Workington Iron Company, who have secured the largest property in Mysore to serve their manufacture of spiegel and ferro-manganese in Cumberland; and the Carnegie concern, represented in the Central Provinces by Mr. Kellerschon, whom we gladly welcome as one of our new members.

Of the other minerals which are now contributing to that desirable growth of complexity and consequent increased stability of the mining industry of India, I might mention the magnesite deposits of Salem, where Mr. H. G. Turner has, I hear, at last found an outlet for the remarkably pure magnesite which he converts into crystallized magnesia—artificial periclase—in the electric furnace. In Singbhum the prospecting operations undertaken by the Geological Survey are being extended by the Cape Copper Company under the management of one of our guests, Mr. J. E. Snelus, who bears a name known and respected by every student of the Royal School of Mines. Encouraging results are also being obtained in Sikhim by our enterprising friends, Messrs. Burn and Company, who are well known in India for the many successful works they have undertaken above ground and below ground, although they cannot be trusted, according to our City Fathers, to be equally efficient in building structures in the air!

Satisfactory progress is reported from Burma also, where the enterprising pioneers of gold-dredging on the Upper Irrawaddy have been able this year to pay their first dividend, and without having had an opportunity so far of examining their balance sheet, I understand from a critical shareholder that this distribution of profits is not made without due regard to the liabilities of the Company. In South Burma, through the energy and ability of Mr. Snow, in tackling the local difficulties of labour and jungle, a promising lode of tin-ore has been opened up by the Burma Development Syndicate to supplement the less satisfactory local industry in washing alluvial tin. The petroleum fields, with which I have been forced to become familiar during my recent exile as President of the Oilfields Commitee, still support what is the most satisfactory of our mineral industries from the point of view of the political economist; of the crude oil now being obtained in increasing volume, 95 per cent. is turned to marketable account in a manufactured form to the displacement of foreign materials, and the only fraction exported is that turned into manufactured products in the country of production.

I will not tire you with further dry details about minerals; but, before passing on to a wholly different subject, I wish to draw your attention to a small local industry, directly dependent on mineral products and one that should be capable of greater development and of greater value to the country. I refer to the manufacture of ammonium sulphate, which is at last successful through the steady persistence of one of our members, Mr. W. R. Criper. Mr. Criper told me, just before dinner, that he has at last found a steady market for his full production; but I was sorry to hear from him that the whole of his out-turn is sent out of the country. Here we have now being exported the very substance that enabled Java and Mauritius combined last year to dump into India sugar to the value of 4½ million sterling, while so much money is being spent in attempting to encourage the production of our own sugar. I hope our Mozufferpur planters who are said to be turning to sugar as a substitute for indigo planting (which has had a severe blow from the European Chemist) will learn the value of ammonium sulphate and will recognise the fact that it is now being made near their own doors, and will soon be manufactured in still larger quantities 200 miles nearer at Giridih.

The Government of India, like all other institutions conducted for the public good, comes in for its share of criticism on the part of those who, by right or assumption, consider it their duty to see that the country is properly conducted. So far as my small share of responsibility is concerned, criticisms of all kinds are welcome: some of those I get give us new views of the questions on which we try, with partial success, to be efficient; others are funny enough to relieve the tedium of dry official work.

Sir Thomas Holland then referred to certain friendly criticisms that had recently appeared in the local press, and proceeded as follows:—

But the choicest sermons, after all, are those that sometimes appear in the papers at Home, where it is obviously difficult for those who rush into print to form a clear picture of Indian conditions. I am especially indebted to the courtesy of the Editor of the *Mining Journal* for occasional evidences of the unusual interest which his paper has taken during the past year or so in the attitude of Government to Indian minerals. I will take the latest as an example of the rest; and as I refer only to an article to which my attention has been especially directed by a marked copy from the office of the journal, I hope it is not unfair to assume that it is a representative sample of the ideas there entertained regarding our shortcomings. As an appendix to a short review of our last statement of mineral production, a leading article in the *Mining Journal* of November 28th is devoted to a discussion of the "obscurity surrounding mining tenure in India." The regulations issued by the Government of India are regarded by the writer as "unsatisfactory." I agree with the writer of the article in the use of this curt, if somewhat ambiguous, description of the Rules which are intended to guide the Local Governments in the grant of areas for prospecting and mining under licenses and leases; but I would use the word "unsatisfactory" in quite a different sense to that which, I imagine from the context, is the meaning of the writer of the article. In view of the way in which the local authorities are liable to regard the maximum privileges defined in the Rules as those that might be *ordinarily* granted, the Rules, as they now stand, may be unsatisfactory from the Government point of view; but so far as the prospector and miner are concerned, the privileges obtained under the existing Rules are more generous than those granted in most mining countries, and were purposely intended to be so as the result of the study of the latest regulations in force elsewhere. During the past two years we have taken every opportunity of collecting the views of those actively engaged in prospecting and mining in lands of which the Government hold the mineral rights, and the evidence we have obtained is distinctly in favour of the Rules as a whole; a few obvious improvements have been suggested, and in due course will presumably receive the favourable attention of Government; but when, last year, a committee was appointed to consider the replies received from those consulted regarding proposed changes in the existing system, the members of the committee found it easier to produce reasons in favour of increased limitations than in favour of granting additional privileges. So far as I can judge from the remarks of the *Mining Journal* there is a misapprehension regarding the precise form in which mineral "concessions" are granted. The writer of the article seems to think that because the Rules are what he describes as "permissive" and not "obligatory," they involve no obligations on the part of Government. He has overlooked the fact, however, that the Rules merely indicate the lines and limited conditions under which licenses and leases are granted. The licenses and leases themselves are legal documents executed in the usual way by both parties to the contract, and are as binding on the Government as on the lessee, the privileges and covenants of both parties being clearly defined to the satisfaction of both before signature. Such a document is capable of legal test, like any other contract, before the highest tribunal accessible in and from the Province in which it is granted.

It is hardly necessary for me to enter into a discussion regarding the merits and faults of the existing system of granting mining concessions in India: most of you know the advantages you obtain by leases in Government lands. How many of you who are engaged in coal mining in zemindari lands pay less than four times the royalty you would be charged in Government lands? Not one of you. How many of you pay, in addition to your royalty and high rental charge, a *salami* that is never exacted by Government? All. And how many of you pay large sums before the execution of a lease that are not mentioned at all in the document? Your laugh is a sufficient answer to the question.

Now, before I leave this subject there are one or two points in the article that I have been discussing which touch all of you, and should not be allowed to stand unchallenged. The *Mining Journal* says, "We are not alone in taking exception to the undefined powers of the Executive in the control of mining. The President of the Mining and Geological Institute of India, in his presidential address earlier this year, protested against the *secrecy* and *suddenness* with which drastic alterations of important conditions could be effected."

Before dealing with this interpretation of Mr. Miller's words, let me first ask you, in the presence of Mr. Miller himself, whether the address of the genial President who has just given up the chair, is a sufficiently full account of the actual circumstances referred to. Mr. Miller left his hearers to infer that rules made under the Mines Act of 1901 are "open to alteration or deletion at the will of the Government of the day by merely publishing them in the Indian official Gazette for a short period." These are the words as reported in our *Transactions*, and it seems desirable, therefore, that the whole circumstances should be recorded in the same publication. In the first place, neither the rules referred to as inconvenient, nor any other rules under the Mines Act, have ever been issued for general criticism before being accepted by the Mining Board, on which you are represented by two non-officials out of the five members. Then, if rules are framed in spite of your representatives on the Board, it is *their* duty to ascertain the views of the mining community during the three months of publication, even if they have neglected to defend your interests when the rules were first placed before the Board for consideration. If then it be true that "very few persons outside the Mining Board heard anything of these new rules until they came into force," it is the fault of your own representatives, not of the Government. Take your own men and do what you will with them, but don't blame the Government for their shortcomings. The Mines Act purposely granted wide powers for the framing of rules, and rightly so, as Mr. Ashton pointed out at the last Annual Meeting, because of the new conditions under which it was to be tried, and the Government devised this simple scheme for obtaining your views before and after the drafting of each rule.

The rules were thus passed by your own representatives before being issued in draft form for general criticism.

Where is the *secrecy* in this? The draft rules were published for three months in order to invite your criticisms. Where is the *suddenness* that the *Mining Journal* complains of? The use of such expressions requires no comment from me. I am not speaking to Government officials, but to mining men who know that I speak the truth, who know that it is the aim of Government to do what is best in the interests of the mining industry and the country.

In referring to the "unsatisfactory" nature of our rules for the grant of leases and licenses, the *Mining Journal*, in the same article, refers to the delays likely to occur in an administration like ours, "unversed in mining," when unforeseen difficulties arise; and, as an instance of such, they quote the experiences of the Burma Development Company, which were referred to in a previous issue of the *Journal*. I have taken the trouble to look up this reference, and find that, at a meeting of the Company, the Chairman referred to the fact that in attempting to manufacture a suitable explosive to supplement their requirements, they found themselves in conflict with the Explosives Law. Our explosives laws were not, till quite recently, of a very unusual character, and those of you who have followed recent events in Bengal will probably agree that laxity in the control of explosives manufacture cannot be supported by many sound arguments. Naturally, a mining man, like ordinary mortals, must be subject to the laws of the country in which he works, and the country would be intolerable if the laws were not impartially enforced. In this particular instance, I am willing for the Government to be judged by the very people whose supposed grievance is taken up by the *Mining Journal*: Mr. Snow, the Manager at Maliwun, as I know from a letter received from him long before this copy of the *Mining Journal* reached me, and presumably also his Board in London, are perfectly appreciative of the way in which the Government readily assisted the Company in the exceptional circumstances in which they found themselves through no fault of the Government or of the Mining Rules. They might well pray to be delivered from their friends.

Then the *Mining Journal* wishes to know why a mineral "explorer" should be prevented from "turning up" the surface more than 6 feet, "as mentioned in the account of the wolfram discovery in Nagpur, which we print this week." If the Editor had "turned up" the account referred to before passing this article, he would have found that the depth prescribed in the district for exploring licenses was not 6, but 8 feet, although it was at 6 feet that Mr. Kellerschon found the wolfram. This small error is unimportant except as an illustration of the consistent way in which the writer of this article has been careful, even in small matters, in verifying his data. Of course every one of you knows perfectly well why it is not possible, in a simple ten-rupee exploring license, involving no covenants or deposit, to grant unlimited powers to disturb forest lands. The object of an exploring license is merely that of the passport, a sort of letter of introduction to the subordinate forest and other officials whom the explorer may meet in his wanderings. He can obtain the greater privileges and undertake the real obligations of the prospecting license when he thinks it desirable; he can follow up his license with an application for a lease for 30 years to which he has, under the rules, an indisputable claim.

According to the *Mining Journal*—I am still referring to the same article—Indian mining concerns start with an initial disadvantage on account of our mining law and administration. Whatever drawbacks there may be in the system—no one claims that it is perfect—results show that the ups-and-downs (recently they have been all ups) are due to quite other causes, and the way in which you have been able to respond to the recent "boom" in manganese shows how readily the conditions in India can be turned to profitable account. During 1905 only 80 applications were received in the Central Provinces for licenses and leases; in 1906 they rose to 344, while in 1907 the applications amounted to 1,541. I have taken the Central Provinces as an illustration, because most of the land there belongs to Government, and the increased activity was mainly due to manganese, the mineral I have referred to, as an instance of the way in which the country can respond to the changes in economic conditions under the present "unsatisfactory" system.

The *Mining Journal*, still in the same leading article, have "high authority" for the belief that the "concession system" is devised to meet the "convenience of 'persons of consideration' who are well able to get all they want." So far as my short career is concerned, I have not had the privilege of meeting these 'persons of consideration.' Perhaps some of you know what is meant by this cryptic remark; it is beyond me. If there be such 'persons of consideration' in India, and they have been receiving any "consideration" known as that variety distinguished by inverted commas, I shall be glad to be put into touch with them. My colleagues and I are, however, generously excluded from the "reflections" of the *Mining Journal*. Speaking for myself, I have no desire to be dissociated, either on the score of competence or honesty, from the Government or the splendid body of Civilians with whom it has been my privilege to work during the past 18 years. I prefer the condemnation of those—

"Of whom to be dispraised were no small praise."

Let us turn now to one who merits the praise of us all, and whose memory will be respected in India so long as a pit-head frame stands in the coalfields—our friend Pickering. Out of the fertile brain of this Jupiter, from which this Institute sprang three years ago, there has now sprouted another Minerva in the form of a home edition of ourselves. I wish to draw your attention to the fact that Mr. Pickering will be glad to receive notice from any of you who may visit England on leave this year, in order that he may have your co-operation at the next annual gathering of Anglo-Indian mining men in London.

Gentlemen, I have now but a short farewell message to deliver, and then I shall have done.

The time is arising when the mineral question in India, in its geographically isolated position, will be chief among its political problems. We have an enormous population, rapidly learning the arts and luxuries of civilization, and there is not one among the luxuries of this, and the necessities of the next, generation that is not dependent on mineral products. This is not a local or provincial question, but one of imperial importance. The resources of the Native States are as much a part of the fabric as the minerals in Government lands. Most of you hold your leases from zemindars, to whom the minerals were ceded with the surface rights in the Permanent Settlement of Bengal. But Government are, in my opinion, still responsible as Trustees of the country to see that every reasonable care is taken of minerals as much as of the lives of your workers. I would as soon concede the power of life and death to an administration as freedom in disposing of its minerals. When, therefore, this question of economy becomes acute, as it will do in the next generation, remember that this Institute was founded to forestall Government interference, and to make restrictive measures unnecessary. I wish the Institute, the industry, and every one of you success.

Mr. Ashton then proposed "The Guests." He said they had not as many guests at the dinner as they would have liked to have, and consequently those who were with them were all the more precious. They had two very interesting guests in Mr. McMurtrie and Mr. Mountain, the latter of whom had spoken to them that morning on the advantages of electricity as applied to mining. He was sure they were all convinced by what he said, that the time had come when they would have to give up grubbing for outcrops in the courses of streams and go down to the deep coal, of which there were enormous quantities in India. The only way they could do that satisfactorily and economically was by the use of electricity. Another guest was Mr. Snelus. He knew they had the sympathy of the distinguished head of that province, Sir Edward Baker, whom he thought they would have had with them that night if his presence had not been required to complete the assembly at Government House. As it was, he had sent them a message to say that he would visit the colliery districts at the end of March or beginning of April (applause). They would all agree that it was very brave of his Honour to do this because it was at that very time last year that the districts were visited by a terrible cholera epidemic. The Executive Government was represented that night by Mr. B. Robertson, C.I.E., I.C.S., the head of the department which guided their commerce and set them an example in industry, and he had to couple that gentleman's name with the toast.

Mr. Robertson said it had been a great pleasure to him and all the guests to meet the members of the mining industry. It was the first time he had come in contact with the great coal-mining industry of Bengal, for his own experience had lain in the Central Provinces. There very great strides had been made in the mineral industry, and one of the most notable features in that development had been the co-operation of the members of Government and the representatives of industry. He had not yet made the acquaintance of the coal-fields, but he hoped to pay a visit to Jherria next month and possibly renew his acquaintance with many of the gentlemen he had met that evening. He wished to express on behalf of the guests the regret they all felt that they were so soon to lose the distinguished services of Sir Thomas Holland. Sir Thomas had done a great work for India, and that work would remain and leave its impress on the future. They all trusted he would be spared for many years to work at Home, and that he would have as successful a career there as he had had in India.

Mr. W. Miller submitted the toast of "The President." They were all, he said, very pleased to see Mr. Graves, their late Honorary Secretary, in the chair, and they all joined in very heartily congratulating him on his elevation to the presidency of the Mining and Geological Institute of India. It was a position Mr. Graves would honourably fill, and he was sure that the Institute under such able guidance would go on and prosper during the current year.

Mr. Graves briefly replied saying he would do his best to ensure the progress of the Institute, and the proceedings then terminated.

EXCURSION.

On Saturday morning about 50 members of the Institute, with some guests, embarked at 8 o'clock at

Chandpal Ghat on the *S. S. Howrah* which was kindly lent by the Port Commissioners. After a short but pleasant run down the river they landed at the new landing stage of the Sibpur Engineering College. There they were met by the Principal, Mr. B. Heaton, and the Staff of the College, Messrs. Brühl, Everett, Monckton, Richardson, Roberton, and Tate. After being formed into four parties under the guidance of those gentlemen they proceeded round the engineering shops, and the various laboratories, and lecture rooms, where more than two hours were very profitably spent.

The College workshops were originally built in 1878 by the Public Works Department for the Calcutta Workshops division. On the closing of the Workshop Division in 1897 the shops were handed over to the College fully equipped. This has been of great advantage. No other College in India has such extensive workshops, and the fact that they have been equipped by practical men with a view to turn out work, actually required by the Public Works Department, as economically as possible, has ensured the work done being of a more practical nature than might have been the case had they been equipped merely from an educational point of view.

Carpenter's Shop.—This shop can accommodate 100 students at one time, and all students have to work in it for at least 12 hours a week during their first year in College. Some classes of students spend considerably more time in it than this, and nearly all the furniture and other wood work required for the College is turned out here. Most of the work is done by hand, but the shop is provided with electrically-driven band saw for small works, frame saw for large logs, planing machine, circular saw and mortice machine.

Smithy and Boiler Shop.—There are 40 forges in this shop and 76 students (2 working together and no striker or coolie of any kind is allowed to assist) can be accommodated at one time. All students have to work in this shop for a year and to pass a practical examination in forging and welding before they are promoted to the senior classes.

The draught to the forges is supplied by a No. 4 Roots blower worked by an electric motor with counter shaft. The flues are of masonry below floor level. All the iron work required for the College is manufactured in this shop, and when College requirements allow, outside work chiefly for the Public Works Department and District Boards is undertaken. This allows the students to get a good training in roof truss and structural work generally. The hull of the College launch "Lilian" (about 20 tons) was turned out in this shop.

Foundry.—The foundry is 120′ × 50′ and is provided with a 5-ton travelling crane. The crucible can at one run do a one-ton casting. There is also a small brass foundry, and the shop is well supplied with small and large patterns.

All apprentice students work in the foundry for 18 hours a week in their 3rd year.

Machine Shop.—This shop is equipped with lathes ranging from 30 feet to 6 feet beds, planing machines from 20′ to 4′, with a variety of drilling and shaping machines, a small emery grinder, a twist-drill grinder, a screw-cutting machine, and a full supply of the usual small tools. The line shafting is electrically driven.

Power House.—All the machines in the shops are driven by electric motors. The class-rooms and residental quarters are also provided with electric light and fans.

The current required is generated in a large packa building situated in the centre of the shops.

There are two multitubular boilers working at 140 lbs. and supplying steam to two 70 B.H.P. compound engines. The engines have 12¾″ and 8″ cylinders and 14″ stroke; one has a surface and the other a jet condenser. They are both governed by Hartnell governors. Both boilers and engines are by Marshall of Gainsborough.

Pumps—2 Duplex Worthington 4½″ 2¾″ by 4″ stroke.

The current is generated by one of 2 multipole triphase alternators with exciters on the same shaft by Brown Boveri

B.H.P.	amps	volts	revolutions
60	130	220	500

Each unit is capable of developing the current required, and each boiler, engine and dynamo is worked alternately.

Electric light installation.—The electric light and fans are worked by direct current at 110 volts. In the electric light house the triphase current is transformed by a rotary Oerlikon converter. The necessary switch board and other accessories are provided, as well as a battery, which is charged from the dynamo and capable of storing up electric energy for the purpose of supplying current lights and fans during the hours the generator is not worked.

In this house there is also a 40 B.H.P. compound high speed engine fitted with shaft governor and driving a 2-pole shunt wound dynamo at 425 revolutions and capable of developing 240 amps at 120 volts, the steam being generated in a multitubular boiler by Hornsby of Grantham. This plant is useful as a standby.

There are also a Hornsby-Ackroyd 7½ B.H.P. experimental oil engine and a Koerting gas engine working a 120 volt 200 amp multipole shunt-wound dynamo.

A small workshop in this building is equipped for testing and repairs in connection with the College lights and fans.

The entire work of the electrical installation is done by students, who are selected for the electrical department, after they have passed the general Overseer examination of the Apprentice Department. They take their turn of duty on the switch board of the main generating station and of the transforming station and execute any repairs necessary for the maintenance of the installations. As some of the underground mains are far from perfect they get plenty of practice in testing for faults and repair of mains.

Motor Mechanic Driver Class.—This class was started in November 1907 with the intention of training boys of the *mistri* class so that they would become useful to car-owners in doing ordinary running repairs instead of their having constantly to send their cars to a repair garage. The boys of this class are first trained in fitting work in connection with motor cars and are then put through a course of tyre repairing, and then driving: but throughout the proper maintenance and repair of cars is made a much more prominent object of the training than mere driving. Sixteen to twenty students are trained each year, and the course extends over 9 months. The class is at present in an experimental stage.

There are at present four petrol cars of different makes and powers available for practice.

Testing Laboratory.—This is provided with a 100 ton Buckton testing machine with automatic recorder; an electric motor for working it is provided, but it can also be worked by hand. At the time of the Institution's visit some of the senior engineer class students were making tests on specimens of Indian timbers. Cement testing and other smaller testing apparatus form part of the equipment.

The College class rooms, physical, chemical, metallurgical and mathematical laboratories were also visited, and Professor Brühl showed on the screen some interesting slides of gold-bearing quartz.

The mining department was visited. It is fully described in the paper read by Mr. Roberton at the meeting of the 29th January (see page 45 of this volume of the "Transactions").

Transactions
of the
Mining and Geological Institute of India.

Part 2.] 1909. [November.

Mr. Mountain's Remarks on the Paper by Mr. Miller on the subject of the Electrification of Dishergarh Colliery.

It appears that at present an air compressor is being used to do the whole of the pumping, which consists of 19 pumps of various sizes. To arrive at an approximate figure of the power which is being developed and what proportion of that power is useful, the following figures may be taken.

The author states that the air and steam cylinders are both of the same size, namely, 30″ × 60″, and run at 40 revs. per minute at a steam pressure of 50 lbs. per sq. inch. The Indicated Horse-power in the steam end is 210, and the Brake Horse-power is 180. The capacity of the compressor may be taken at say 1,560 cubic feet free air per minute at 50 to 60 lbs. per sq. inch pressure.

The overall efficiency of this plant between the effective horse power of the engine and the actual work done in the water cannot be taken at more than 25 per cent, and since the useful work done by the compressor is 180 B.H.P. the available power at the pumps will not be more than 45 H.P.

To drive this plant two boilers 30′ × 7′ are required, and these, with good coal, should evaporate from 4000 to 5000 lbs. of water per hour each. On the consumption of coal given, namely, 374 tons per month, the consumption of coal per B.H.P. per hour, assuming 30 days per month, and 10 hours per day, is :—

$$\frac{374 \times 2240}{10 \times 30 \times 180} = 15{\cdot}6 \text{ lbs. of coal per B.H.P. per hour.}$$

The author states that the coal used is 374 tons per month, and the consumption worked out on the basis of the actual work done comes to 62·4 lbs. of coal per B.H.P. per hour. From these figures it will be seen that transmission of power by means of compressed air is very wasteful. As an actual case of the saving effected by adopting electricity in place of compressed air as a means of transmitting power, the figures obtained from an actual conversion may be of interest.

At Clifton Colliery, near Nottingham, an air-compressor driven by means of a slow speed horizontal engine was used for driving the various pumps and haulage gears, and the I.H.P. of the engine required to drive these machines was 582. The owners of the colliery came to the conclusion that this system was very inefficient, and decided to adopt electricity in place of compressed air. A crankshaft generator mounted direct on the flywheel of the engine was supplied by Messrs. Ernest Scott and Mountain, Ltd., and the existing engine was used, the compressor cylinders only being removed. On this system for doing exactly the same amount of useful work the I.H.P. on the engine was only 166, the saving being the difference between 582 and 166 I.H.P. On account of this it was possible to dispense with two boilers, and still have a very considerable margin of spare power available for other purposes.

To return to the paper, the author states that under the new system of electric drive it is proposed to have 18 pumps consisting of :—

	Actual h.p. in work.
8 bailing pumps, pumping 800 gallons per hour against 100 ft. head ..	·4 × 8 = 3·2
7 dip pumps, pumping 1000 gallons per hour against 400 ft. head ..	2 × 7 = 14
3 main pumps, pumping 6000 gallons per hour against 400 ft. head ..	12 × 3 = 36
TOTAL ..	53·2

He (Mr. Mountain) would propose that the 15 bailing and dip pumps should all be duplicates, but fitted with 2 h.p. motors on the bailing pumps and 4 h.p. on the dip pumps.

The power required, therefore, for driving these pumps will be as under :—

8 bailing pumps,	2 h.p.	.. .. =	16 h.p.
7 dip pumps,	4 ,,	.. .. =	28 ,,
3 main pumps,	20 ,,	.. .. =	60 ,,
	TOTAL	..	104 ,,

Taking the efficiency of the motors as 85 per cent. the power required will be :—

$$\frac{104 \times 746 \times 100}{85} = \text{say } 90 \text{ k.w.}$$

Running 10 hours per day, and 30 days per month, 27,000 units will be required per month.

	Rs.
Taking the cost per unit at one anna, the cost per month will be	1,680
as compared with the author's estimate of ..	1,754

These costs, however, are based on the assumption that all the motors will run continuously at full load, and as this will never be the case, the actual cost of running may be safely taken at, say, from 1,200 to 1,300 rupees per month.

At this point it may be interesting to point out that in England it is usual to supply current for driving pumps and fans and any machinery which runs practically constantly at a much lower rate than for haulage or other intermittent work. If a flat rate is charged this will be less in a colliery where the greater proportion of the power is used for pumping than in a colliery where the greater proportion is used for haulage.

The cost per water h.p. with current at one anna per unit with plant as proposed above, on the assumption that the motors are always fully loaded, will be :—

$$\frac{1680 \text{ Rs.}}{300 \text{ hrs.}} = \text{Rs. } 5{\cdot}6 \text{ per hour.}$$

$$= \frac{90 \text{ annas}}{53 \text{ H.P.}} = 1{\cdot}7 \text{ annas per water H.P. per hour.}$$

With larger pumps and heavier heads the efficiency of the pumps would be slightly higher, and the cost per water h.p. would be correspondingly reduced.

Haulage.—It appears that the following plant is at present installed :—

No. 1 Main Rope Haulage	156 tons	in 16 hours	= 9·8 tons per hour.
No. 2 ,,	96	,,	= 6 ,,
No. 3 ,,	96	,,	= 6 ,,

Total tons per day of 16 hours = 348 tons, or say 22 tons per hour.

The new haulages proposed are to be of increased capacity as under :—

No. 1 = 300 tons	in 16 hours,	say 19	tons per hour.
No. 2 = 200	,,	,, 13	,,
No. 3 = 200	,,	,, 13	,,

Horse-power required for main and tail haulage at 10 miles per hour.

Actual Incline in Inches per Yard.	Virtual Incline in Inches per Yard.	Load in tons.										
		5	7·5	10	15	20	25	30	35	40	45	50
−2	0	0	0	0	0	0	0	0	0	0	0	0
−2	1	8·3	12·5	16·6	25	33·2	41·4	50	58	66·4	76	80·8
0	2	16·7	25	33·3	50	66·6	83	100	116	133	150	166
1	3	25	37·7	50	75	100	125	150	175	200	225	250
2	4	33·4	50	67·5	100	134	167	200	233	270	300	334
3	5	41·5	62	83·5	125	167	208	250	290	334	375	416
4	6	50	75	100	150	200	250	300	350	400	450	500
5	7	58·3	87	117	175	234	294	350	408	468	525	588
6	8	66·3	100	133	200	267	333	400	465	532	600	666
7	9	75	112	150	225	300	375	450	520	600	675	750
8	10	83·5	124	166	250	333	420	500	580	664	750	830
9	11	91	137	183	275	366	459	550	640	732	825	918
10	12	99	150	200	300	400	500	600	696	800	900	1000
11	13	108	162	217	325	433	542	650	755	868	975	1080
12	14	116	174	233	350	466	584	700	815	932	1050	1168

or a total of 700 tons per day of 16 hours, say .. 45 tons per hour.

The gradient in all cases is 1 in 5 or say 7″ per yard against the load, and an average speed of 5 miles per hour has been assumed in all cases.

It is next necessary from these figures to arrive at the power required to drive these haulage gears, and to obtain this it is necessary to find the number of tubs per run which it is necessary to draw to obtain the required quantity of coal.

Assuming that each tub holds 13 cwts. of coal, and that the weight of each tub full and its proportion of rope is one ton, the times taken for a complete run on each road at five miles per hour are as under :—

No. 1 road, 3000′ long	..	7 minutes per run.
No. 2 road, 1600′ ,,	..	4 ,,
No. 3 road, 2600′ ,,	..	6 ,,

To arrive at the number of runs per hour on one road, 7 minutes each way with 6 minutes at each end for changing, which makes say 20 minutes in all for the total run, this gives three journeys per hour.

Nineteen tons of coal are to be hauled per hour, which means 6·3 tons per journey, which at 13 cwts. per tub will require 10 tubs to each train. The weight of coal, tub and rope is say one ton, so that the total weight of the train may be taken at 10 tons.

From the table of h.p. required for various roads on various gradients, it will be found that on a gradient of 7″ per yard for 10 tons at 1 mile per hour, about 15 h.p. are required, so that at five miles per hour 75 h.p. will be required.

On No. 2 road, similar calculations to the above show that the total time for a journey would be 15 minutes, or a total of four journeys per hour. To raise 13 tons per hour 5 tubs per train would be required. The weight of these would be again approximately 5 tons, and at 5 miles per hour 38 h.p. will be required.

Similarly on No. 3 road three journeys per hour can be made, and to obtain 13 tons per hour 7 tubs per train will be necessary. As before, assuming the weight to be 7 tons, at 5 miles per hour, the horse power required would be 50.

The total h.p. for the three gears will then be :—

No. 1 road	..	..	..	75 h.p.
No. 2 road	..	..	..	38 ,,
No. 3 road	..	..	..	50 ,,
		TOTAL	..	163 ,,

Here again it may be mentioned that with a view to keeping down the number of spare parts these three gears would probably be best made duplicates and all fitted with 75 h.p. motors. In the case of the No. 2 road the motor would only be working at approximately half load, but with first class motor of modern construction, the efficiency at half load will not be very much less than at full load, but in working a motor at half load in this way it is very necessary that the motor should be of first class construction as otherwise the efficiency will be so low as to seriously affect the cost of running the plant.

To arrive at the consumption of current on these three motors, it must be borne in mind that power will only be taken when the trains are being drawn out as they will run back by themselves, and, of course, no power will be required whilst changing.

To arrive at an approximate figure, the running time may be taken as one-third of the total time.

To allow for the extra power for acceleration it may be assumed that the average h.p. of the three gears is 60, and that this is required for a third of each running hour. The number of units required will, therefore, be :—

$$\frac{60 \times 746 \times 100}{85} = \text{say 50 units per hour}$$

or for 16 hours per day,
and 25 days per month = 20,000 units per month
which at 1 anna per unit = Rs. 1,340 per month.

An output of 700 tons per day for 25 days = 17,500 tons per month, and the total cost per month for current for this output is Rs. 1,340. The cost per ton hauled is therefore .. .. 1·23 annas.

On the present system of haulage with compressed air, the daily output is 348 tons, or a monthly output of 8,800 tons for 25 days per month.

The cost for this output per month is as under :—

				Rs.
No. 1 road	..	..	..	686
No. 2 ,,	..	..	..	488
No. 3 ,,	..	..	..	488
		TOTAL	..	1,662

which is equivalent to 3 annas per ton per month, showing a saving in favour of electrically driven haulage of 1·77 annas per ton.

To compare the total saving of the two systems on the same basis it is necessary to adjust the cost of electric haulage to the same output as the compressed air.

From the figures before given, for Rs. 1,340 per month 17,500 tons of coal are raised, and therefore 8,800 tons of coal can be raised for Rs. 670.

The total saving by adopting electricity for both pumping and haulage would be as under :—

		Compressed air.	Electricity.	
		Rs.	Rs.	
Pumping	..	1,754	1,680	
Haulage	..	1,662	670	(on same basis as compressed air).
TOTAL	..	3,416	2,350	

This shows a saving in favour of electricity of 1,066 rupees per month, or say £860-0-0 per annum.

Assuming that current is not available from a Supply Co., and that the owners decide to instal electrical generating plant, the following figures may be of interest :—

The following power is required :—

For pumping	..	..	..	90 k.w.
,, haulage	..	..	..	150 ,,

or say a total of 250 k.w. Of course, if the pumping can be done at night and haulage by day, the size and cost of the generating plant can be considerably reduced.

To run a 250 k.w. generating plant, two 30′ × 7′ boilers would be required. The cost of this plant would be, approximately	£2,500 0 0

The running cost would, therefore, be :—

Interest and depreciation at 10 per cent. per annum	=	Rs. 310 per month.	
Coal 6 lbs. per I.H.P. Assuming an average of 300 I.H.P. required for 14 hours per day = $\frac{300 \times 6 \times 14 \times 30}{2240}$ = say 330 tons,			
which at Rs. 3 per ton	=	990	,,
Wages and Sundries, say	=	150	,,
Depreciation on boilers	=	50	,,
Total cost per month	=	1,500	,,

The Supply Company charge for current for pumping Rs. 1,662 and for haulage Rs. 1,340, or a total of Rs. 3,002, which is Rs. 1,502 per month more than the cost of running one's own plant.

This shows a further saving of roughly £1,000-0-0 per annum.

The saving in favour of putting in one's own generating plant is still more marked if the two systems are compared on the increased output of 17,500 tons per month.

	Rs.
Working on compressed air, for pumping the cost would be as before	1,754
Working on compressed air, for haulage ..	3,300
TOTAL ..	5,054

The saving by putting down one's own generating plant is then Rs. 3,554 per month, or say £2,800-0-0 per annum, which is sufficient to pay for one's generating plant in the first year.

The annual saving by adopting electricity on the various systems may be briefly put as under :—

Saving on electrification by Mr. Miller's scheme, if he takes current from the Supply Co. at one anna per unit, based on an output of 8,800 tons per month ..	=£ 860 0 0
Further saving by generating with private plant for the 17,500 tons output	=£1,000 0 0
Total saving over present system on increased output by using one's own generating plant	=£2,800 0 0

This last figure is based on the assumption that both systems are required to give the increased output of 17,500 tons per month.

The following approximate figures may be of interest as showing the amount of work which can be obtained for a given outlay by means of electric drive :—

Taking current at 1 anna per unit, 16 units, costing 1 rupee, will deliver 100 gallons of water 100 feet for 5 hours, or 100 gallons 500 feet for one hour.

The same outlay, namely one rupee, will run an endless rope haulage gear, delivering 30 tons of coal per hour along a road 1000 yards long with a gradient against the load of 3″ per yard, for one hour.

The same outlay will again run a main rope haulage gear drawing a train of tubs and rope weighing 4 tons at a speed of 5 miles per hour, against a gradient of 3″ per yard, for one hour.

For ventilation, 16 units, costing 1 rupee, will drive a fan delivering 40,000 cubic feet of air per minute against $1\frac{1}{2}''$ water gauge for one hour.

It will also drive a compressor capable of delivering 100 cubic feet of free air per minute at 80 lbs. pressure for one hour.

For use on hand drills working in granite this air will work three drills of No. 1 size at 2,000 blows per minute drilling $3\frac{1}{2}''$ per minute, or $2\frac{1}{2}$ drills of No. 2 size giving 1,700 blows per minute drilling $4\frac{3}{4}''$ per minute, or 2 drills of No. 3 size at 1,500 blows per minute drilling $7\frac{1}{2}''$ per minute.

In putting down plant in an Indian colliery, a point it is well to consider very seriously is the type of pump to be used. It must be borne in mind that for Indian work it is necessary to have the simplest possible apparatus, and also plant of the most reliable character to enable it to be run satisfactorily with Indian labour, and this applies not only to pumping, but to all classes of machinery.

As regards the engine, there is no question that the slow speed horizontal engine with good governing gear, and for the smaller units arranged for rope drive between the engine and the generator, forms a type of plant which can be recommended for Indian work.

Steam turbines are, of course, only economical as regards first cost and steam consumption when they are of suitable size. The ordinary slow speed horizontal engine of the single cylinder or compound type, or the high speed engine and dynamo, will be found less expensive as regards the first cost than turbines up to a unit of about 350 k.w. In addition to this, however, the most serious objection to the use of turbines in India is the difficulty in getting condensing water, and also water sufficiently cool for condensing purposes. Of course, the quantity of water required for condensing at a high temperature—and in India this temperature would probably range in the cold weather from 80 degrees and in the hot up to 100 degrees—would be very considerable, and even then it would be difficult to get a good vacuum, and the steam consumption of turbines when working non-condensing is, of course, so high that it puts them out of consideration. Even when working on a fair vacuum, *i.e.* 28″, the consumption is often much higher than either a good slow speed engine or high speed engine.

Applying the same argument as regards simplicity to pumping there is no doubt that the horizontal type of three-throw ram pump, when constructed with all its working parts renewable and interchangeable and run at a moderate speed, is in every way more economical and more reliable than the centrifugal pump. The ram or displacement pump will, of course, deliver a definite quantity of water fixed by its displacement and revs. per minute, and the limit of head is dependent entirely upon mechanical strength, the speed remaining the same for a definite number of gallons per minute. With a centrifugal pump the head is proportionate to the square of the speed, and therefore you must run the pump at the correct speed for the head for which it is designed.

In a colliery where a number of dip or bailing pumps, or even main incline pumps, are used, the colliery owner never knows when it may be necessary to shift a pump from one position to another, and if he had a number of centrifugal pumps all designed for definite heads, it would be quite impossible to shift them about and use them in any position as can be done with a ram pump. In addition to this, when pumping dirty water the centrifugal pump is liable to become clogged with dirt, and then considerable wear and tear takes place. There is a further difficulty due to the high speed of the spindle and the wear of the glands in the turbine pump. The attention to the glands, also to the thrust bearing, and, in addition, the careful adjustment required in putting these pumps together when once taken apart, are work which can only be done with very skilled labour.

These remarks respecting the type of pump are made after a considerable experience as a manufacturer of both types, and are based upon results extending over nearly 20 years of colliery work.

He (Mr. Mountain) heard on arrival in India a statement that the electrical plant at the Sodepur pit of the Bengal Coal Co. was not giving satisfaction, and as such a feeling was liable to prejudice the prospects of electrical driving in India, careful enquiries were made, and the plant was found to be working electrically perfectly satisfactorily, not only as regards the generating machinery, but also the haulage and pumping plant, but this installation, though installed for the electrification of a group of collieries, so far only supplies current to the Sodepur pit, or about 80 h.p., whereas the plant is capable of giving an output of 500 h.p.; and it is easy to see that to run a large plant like this for one-sixth of its output cannot mean producing current economically. Some figures are, therefore, given showing the approximate cost of generating plant consisting of two 200 k.w. units or a total capacity of 400 k.w. In addition the cost is given per unit generated, allowing interest and depreciation at 5 per cent. each, assuming that you run 300 working days per annum, 24 hours per day. From this it will be noted that the cost per unit is very low, but of course in collieries the load varies, and as the output taken from the station is always less than its full capacity, a table is given showing what the approximate cost would be per unit on different load factors. It will be noted how very much cheaper the current becomes on a high load factor.

As a basis for estimating the cost of current, the following approximate figures may be taken :—

	£	s.	d.
Two generating sets of 200 k.w. say ..	4,000	0	0
Two boilers, piping, etc.	1,500	0	0
Building	1,300	0	0
Switchboard	200	0	0
TOTAL ..	£7,000	0	0

The following charges will be independent of the number of units generated :—

	£	s.	d.
Interest and depreciation on £7,000 at 10 per cent.	700	0	0
Skilled labour—			
2 men @ £2-10-0 per week	260	0	0
Unskilled labour—			
4 men @ 8/ per week	90	0	0
Oil, stores, etc., say	104	0	0
Repairs, sundries, etc.	200	0	0
TOTAL ..	£1,354	0	0

Working the plant at its full capacity, *i.e.*, at 400 k.w. for say 300 days per annum, 24 hours per day, the units generated would be	2,880,000

The cost per unit, therefore, on standing charges, working the plant at its full capacity, will be :—

$$\frac{1354 \times 240d.}{2{,}880{,}000 \text{ units}} = \cdot 113 \text{ pence per unit.}$$

	£ s. d.
The cost of coal, assuming that six pounds per k.w. hour are used, or say 8,000 tons per annum, at 2/ per ton, will be	800 0 0

The running cost per unit, on full load, will therefore be :—

$$\frac{800 \times 240d.}{2,880,000 \text{ units}} = \cdot067 \text{ pence per unit.}$$

The total cost per unit generated on full load is therefore .. .. ·18*d*. per unit.

By means of a similar calculation it is possible to estimate the cost per unit for any other load, and the following table shows how the price per unit rises as the load factor of the plant falls :—

Hours per day.	Load in k.w.	Days per annum.	Pence per unit standing charges.	Pence per unit running charges.	Total price per unit in pence.
24	400	300	·113	·067	·18
12	400	300	·226	·067	293
12	300	300	·301	·067	·368
12	200	300	·452	·067	·519
12	150	300	·602	·067	·669
12	100	300	·904	·067	·971
12	50	300	1·808	·067	1·875

Mr. W. A. Lee thought that they were particularly fortunate in having put before them the probable results of the electrification of the pumping and haulage of the colliery referred to, and secondly in having had the advantage of hearing Mr. Mountain. Mr. Mountain could speak with authority, and after his remarks he felt there was very little for him to say. On the question of pumping he was asked by Mr. Miller to state the probable cost of pumping by electricity, and he gave him what he believed would be the cost of running each pump per hour, because he had great doubts as to whether Mr. Miller or any of them could really know what amount of water there was in the collieries. The cost of running steam on electrical pumps must depend upon the precise amount of water they were going to pump. All estimates of the quantity of water in collieries must be looked upon with great doubt and even with considerable suspicion, and he should not, therefore, be prepared to accept Mr. Miller's figures as the actual results of working until they had actual trials in the colliery, and so found out by experience what the cost was. Trials of these things should be made underground.

Mr. J. R. R. Wilson, Chief Inspector of Mines, said the paper was certainly of much value, and it was made more valuable by producing the remarks of Mr. Mountain. When he saw the paper the first paragraph to attract his attention was that which said that to electrify these engines and pumps would destroy ventilation. He was very glad to see that because then there would be a chance of getting fans adopted in the mines, and so ensuring efficient ventilation. With regard to the indestructibility of cables, a commission was then sitting to formulate rules to apply to mining. When those rules are published it will probably be found that the Commision do not by any means consider that cables are indestructible. When they are destroyed or fractured the results are, as everyone knows, apt to be very serious.

The President remarked that the electrical people had had a very good innings that morning, and they would like to hear a good deal more about the subject. It would, however, be wise to postpone the discussion until a future meeting, so as to give Mr. Roberton a chance to tell them about the mining department of the Sibpur College which they were going to visit on the following day. Meanwhile on behalf of the members he offered a hearty vote of thanks to the author.

Notes on the Mining Section of the Central Provinces and Berar Exhibition, 1908.

BY

L. Leigh Fermor and J. Kellerschon.

(With Plates I and II.)

CONTENTS.

I.—INTRODUCTION.

It is 48 years since the first industrial exhibition was he'd at Nagpur, the capital of the Central Provinces. This exhibition, due to the initiative of Mr. (later Sir) Richard Temple, the then Chief Commissioner, was opened on the 26th December, 1865, and, although of small dimensions compared with the exhibitions of later days, was a great success; and this in spite of the lack of adequate means of communication with other parts of India. For Nagpur was then 70 miles away from the nearest railway on the Bombay side, and completely isolated from Calcutta, Mirzapur in the North-West Provinces being the nearest point reached by railway from Bengal. Further, the northern portions of the Province were so cut off from the southern by the Satpura Hills that in 1866 another exhibition of similar scope was held at Jubbulpore.[1]

The next exhibition to be held at Nagpur was the one with which these notes deal—known as the Central Provinces and Berar Exhibition, 1908. It was organized by an influential committee, with Mr. C. E. Low, an Associate of this Institute, as Secretary. It was opened by the Hon. Mr. R. H. Craddock, Chief Commisioner of the Central Provinces, on 12th November, 1908, and remained open until the middle of January, 1909.

The scope of this exhibition was mainly industrial, and the following sections were established :—agricultural, textile, mining, miscellaneous, wood and metal, forest, ladies', machinery, and amusement. It is the third of these sections to which the present notes relate. But it will not be out of place to call attention to the great variety of metal wares—in copper, brass, silver, iron, and steel—exhibited from various parts of the Province. They testified to the existence in this Province of considerable skill and artistic taste, and in some cases were not inferior in merit to the productions of the famous metal-working centres of other parts of India. Their variety and beauty came as a surprise, even to the majority of the residents of the Province, and it probably requires nothing but a little encouragement from the residents of, and visitors to, these parts to bring about a considerable revival of the metal-working industries, which from lack of demand for their wares are in some danger of extinction. The most striking piece of work was a magnificent brass door made at Nagpur by Matadin Kasar.

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1 See the Official Handbook of the Central Provinces and Berar Exhibition, 1908, pp. 15—17.

Before noticing the mining exhibits it will not be out of place to offer a few remarks on the geological features and mineral industries of the Central Provinces.

II.—GEOLOGICAL FORMATIONS AND MINERAL PRODUCTS OF THE PROVINCE.

The distribution of geological formations in the Central Provinces and Berar is roughly as follows:—*Alluvium* obscures the older formations in many parts of the province; the most important spreads of alluvium are those in the Narbada valley, stretching from Handia to east of Jubbulpore, and in the valley of the Purna in Berar: *Laterite* is found as cappings to older rocks, usually on the Deccan Trap or the Dharwars: *Deccan Trap* occupies most of the western parts of the Province (including practically the whole of Berar), most of the Satpura Range, and parts of the north-western border (Saugor): *Lametas* are found as a thin fringe to the Deccan Trap formation: *Gondwana* rocks, in some of which coal is found, cover relatively small portions of the surface of the neighbourhoods of Jubbulpore, Mohpani, Chhindwara, Nagpur, Chanda, and Bilaspur: small spreads of *Upper Vindhyan* rocks are found in the north of the province (in Saugor, Damoh and Jubbulpore): a large area of *Lower Vindhyans* gives rise to the Chhattisgarh plain, while a smaller area of the same formation is found near Katni: the *Bijawar* formation is poorly represented (in the Nimar and Hoshangabad districts): and the *Archaean* formations, comprising the *granites*, *gneisses*, *schists* and *Dharwars*, occupy very large areas in the central and southern parts, whilst smaller areas of these rocks are found along the Narbada valley, in the districts of Nimar, Hoshangabad, Narsingpur and Jubbulpore.

There is little doubt that as regards mineral wealth, the Central Provinces is one of the richest provinces in the Indian Empire, and that its mineral industries, now in a state of rapid development, are bound to assume great importance; for a province endowed with great wealth in coal, iron, manganese, aluminium, limestone, and clays, cannot but have a great industrial future before it. And this optimistic view is not diminished when one remembers that many other valuable minerals have been found in this Province, amongst which copper, lead, and wolfram may be mentioned.

The relative importance of the various geological formations can be seen from the following list, showing the minerals of importance that have been found in each :—

1. *Recent and Pleistocene Alluvium.*—Brick clays and kankar (concretionary limestone) .

2. *Laterite.*—Iron-ores, manganese-ores, and bauxite (aluminium-ore).

3. *Deccan Trap.*—Building stone, road-metal, agates, carnelians, onyx, and amethyst.

4. *Lameta.*—Limestone.

5. *Gondwanas.*—Coal, fire-clay, pottery-clay and building stone (sandstone).

6. *Upper Vindhyans.*—Building stone (sandstone).

7. *Lower Vindhyans.*—Building stone (flagstone), limestone, pottery-clays, fuller's earth, diamonds.

8. *Bijawars.*—Iron, lead (and silver).

9. *Dharwars.*—Iron, manganese, wolfram, copper, lead, gold, silver, asbestos, barytes, dolomite, fluorspar, limestone, ochre, steatite, building stone (marble and quartzites).

10. *Gneisses and granites.*—Mica, building stone, road-metal.

Below is given a list of the chief mineral occurrences of the Central Provinces.

TABLE I.

List of the Principal Mineral Occurrences of the Central Provinces.

MINERAL.	Districts where found.
AGATE, CARNELIAN, ONYX, ETC.	Chanda, **Narbada Valley** (**Jubbulpore**).
ASBESTOS	Bhandara.
BARYTES	Jubbulpore.
BAUXITE	**Balaghat, Jubbulpore.**
COAL	Betul (Shahpur), Bilaspur (Korba, Mand River, Sendurgar), Chanda (**Ballarpur**, Bandar, **Warora**, etc.), Chhindwara (**Pench Valley**), Jubbulpore (Lameta Ghat), Narsinghpur (**Mohpani**), Wun.
COPPER	Chanda, **Jubbulpore, Narsinghpur, Drug.**
DIAMONDS	Chanda (Wairagarh).
DOLOMITE	**Jubbulpore.**
FLUOR SPAR	Drug.
FULLER'S EARTH ..	Jubbulpore.
GOLD	Gold washing in several districts. In copper ores of Jubbulpore.
IRON	**Chanda** Hoshangabad, **Jubbulpore**, Narsinghpur, **Raipur**, etc.
LEAD	Hoshangabad, Jubbulpore, Nagpur, Drug.
LIMESTONE	Chhindwara, **Jubbulpore**, Hoshangabad, Nagpur, **Raipur**, Wardha.
LITHOGRAPHIC STONE ..	Raipur.
MANGANESE	**Balaghat, Bhandara, Chhindwara**, Hoshangabad, **Jubbulpore, Nagpur**, Nimar, Seoni, Wun.
MARBLE	Chhindwara, **Jubbulpore**, Nagpur, **Narsinghpur.**
MICA	Balaghat.
OCHRE . ..	Balaghat, Chanda, **Jubbulpore**, Raipur.
POTTERY CLAY ..	**Jubbulpore.**
SILVER	In lead ores of Hoshangabad, Jubbulpore, and Drug.
STEATITE (TALC) ..	Bhandara, Chanda, **Jubbulpore**
TIN	Bastar.
WOLFRAM	Nagpur.

NOTE 1.—Buiding Stone and Road Metal are found in great variety and at many localities too numerous to mention.

NOTE 2.—The most important occurrences are shown in heavy type.

III.—THE MINERAL INDUSTRY OF THE PROVINCE.

The early history of mining in the Central Provinces begins with the reference to the Wairagarh (Beiragúrh) diamond mines in the sixteenth century in the Ain-i Akbari. The much more important coal and iron deposits (the latter had been worked from before historic times) and manganiferous iron-ore of Jubbulpore (which is alleged to have been the source of the famous Damascus steel), attracted little attention till the beginning of the British rule. Certain geological investigations were carried out about 1830 by Dr. Voysey and Capt. Jenkins; and then in 1855 began the publication of a series of papers by the Rev. S. Hislop on the geology and fossils of the Central Provinces, mainly of the neighbourhood of Nagpur. The Geological Survey of India began their long series of papers on the geology, mineralogy and palæontology of this province in 1859, the first important paper being Mr. J. G. Medlicott's Memoir 'On the Geological Structure of the Central portion of the Nerbudda district,' Memoirs, Geological Survey of India, vol. ii, pp. 97-278.

Coal.

The first attempt to work the minerals of this province on modern lines seems to have been that on the Chhindwara coal deposits at Barkui (Pench Valley), by private enterprise in 1860; but difficulties in transport caused the work to be abandoned. This area has, however, become a coal producer since 1903, the chief company being the Pench Valley Coal Company.

In 1861 the Narbada Coal and Iron Company started work on the coal measures of *Mohpani* in the Narsingpur district. Mohpani is now worked by the Great Indian Peninsula Railway Company.

The *Warora* coal field (Chanda district) was opened up by Government, with the establishment of collieries in 1873; they were worked continuously till 1906, when a serious subsidence caused them to be abandoned. The total amount of coal won from these collieries was about 3,000,000 tons, giving an annual average of about 90,000 tons, with a maximum of 153,336 tons in 1902. A fresh colliery has been opened up by Government at Ballarpur in the same district, the first coal being won in 1904.

The number of people employed in the coal mines of this province in 1907 was 1,619. For figures of production see table No. 3, page 120.

Iron.

No serious attempt has ever been made to work the Central Provinces iron-ores on modern lines, although a fair amount of experimental work has been carried on, *e.g.*, on the Chanda ores in 1875. Some of the Jubbulpore deposits were carefully prospected about 1902-03, but no satisfactory results were obtained. The Tata Iron and Steel Co. has, however, recently tested by boring a fine deposit at Dhalli in the Raipur district, and this is being held in reserve as a source of ore for their iron works at Kalimati in Bengal, now under construction. But from time immemorial the *lohars* of the Province have, in many districts, smelted the local ores in their primitive furnaces, and even now in spite of the competition of imported iron numerous furnaces are operated each year. The numbers were 379 furnaces in 1906 and 451 in 1907. The amounts of ore treated were 1,829 tons in 1906 and 1,387 in 1907.

The chief smelting districts are Drug, Jubbulpore, Mandla and Raipur.

Manganese.

The history of the manganese industry in the Central Provinces deserves the titie of romantic. The existence of manganese-ore deposits in the Nagpur and Jubbulpore districts has been long known, but it was not until 1899 that any serious attempt was made to work any of these deposits. In this year the Central Provinces Prospecting Syndicate started work in the Nagpur district; and during the ensuing years the industry extended to the Balaghat, Bhandara, Chhindwara and Jubbulpore districts. The chief operators, in addition to the C. P. P. S., are the Central India Mining Company, Ltd.; the Indian Manganese Company, Ltd.; D. Laxminarayan; the Carnegie Steel Company; and Tata, Sons & Co.

The amount of manganese-ore produced in this province in the year 1907 was 540,577 tons (or one-third of the world's output), more than 10,000 coolies being employed. For figures of production see table No. 4, page 121.

Other Minerals.

The only other mineral at present being worked on an important scale is the Lower Vindhyan *limestone* of Katni. The average yearly output of this mineral product during the 7 years 1902 to 1907 has been 51,000 tons, that for 1907 being 72,022 tons. One hundred and twelve tons of *fuller's earth* were won from the same neighbourhood in 1906: *pottery clay* is worked at Jubbulpore, and small amounts of *red ochre* and *steatite* are won in the same district. Prospecting operations have been carried out for several other minerals, notably on the *copper* deposits of the Jubbulpore district, the *wolfram* deposits of the Nagpur district, and the *bauxite* deposits of the Balaghat and Jubbulpore districts. A small quantity of *asbestos* has been extracted in the Bhandara district.

Gold is known to exist in the province, both in the copper-ores of Jubbulpore and as alluvial gold in streams. At present the production of gold is confined to the aboriginal caste of Sonjharias, three of whom were present at the Exhibition to show visitors their methods of panning. They brought the gold-bearing sand with them from the Sona Nadi, near Pipalgaon in the Balaghat district.

TABLE 2.

Mineral Production of the Central Provinces, 1878 *to* 1907.

Year.	Coal.	Manganese-ore.	Iron-ore.	Limestone (Katni).	Fuller's Earth.
	Tons.	Tons.	Tons.	Tons.	Tons.
1878	57,967	..	..	..	..
1879	33,515	..	..	..	..
1880	31,228	..	..	..	..
1881	67,527	..	..	..	..
1882	91,370	..	..	..	..
1883	115,019	..	..	..	..
1884	121,833	..	..	..	..
1885	119,116	..	..	..	..
1886	117,287	..	..	..	..
1887	128,981	..	..	..	..
1888	157,768	..	..	..	..
1889	144,465	..	..	..	..
1890	137,022	..	5,664	..	..
1891	141,736	..	9,478	..	..
1892	132,005	..	888	..	..
1893	135,118	..	3,332	..	..
1894	140,495	..	6,068	..	..
1895	122,776	..	6,218	..	..
1896	141,185	..	1,827	..	..

TABLE 2—(Continued).

Year.	Coal.	Manganese-ore.	Iron-ore.	Limestone (Katni).	Fuller's Earth.
	Tons.	Tons.	Tons.	Tons.	Tons.
1897	131,629	..	2,387	..	..
1898	149,709	..	3,027	..	..
1899	156,576	..	4,777	..	..
1900	172,842	47,257	2,377	..	.
1901	191,516	81,263	2,680	28,000	..
1902	196,981	76,154	3,133	30,091	
1903	159,154	107,947	1,691	35,238	..
1904	139,027	85,024	2,818	49,847	98
1905	147,265	151,547	2,370	92,170	170
1906	92,848	351,880	1,829	47,836	112
1907	134,088	540,577	1,387	72,022	..

TABLE 3.

Production of Coal in the Central Provinces since 1895.

Year.	Mohpani.	Warora.	Pench Valley.	Ballarpur.	Total.
	Tons.	Tons.	Tons.	Tons.	Tons.
1895	21,393	101,383	..	..	122,776
1896	19,542	121,643	..	..	141,185
1897	19,975	111,654	..	..	131,629
1898	22,472	127,237	..	..	149,709
1899	23,596	132,980	..	..	156,576
1900	39,612	133,230	..	.	172,842
1901	43,046	148,470	..	..	191,516
1902	43,645	153,336	..	..	196,981
1903	31,443	127,623	88	..	159,154
1904	26,618	112,319	..	90	139,027
1905	22,998	123,015	1,104	148	147,265
1906	27,503	32,327	32,102	916	92,848
1907	41,332	..	74,663	18,103	134,088

TABLE 4.

Production of Manganese-ore in the Central Provinces.

YEAR.	Balaghat.	Bhandara.	Chhindwara.	Jubbulpore.	Nagpur.	Total Central Provinces.	Total Indian Production.	Proportion of Total Indian Manganese-ore Production derived from the Central Provinces.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Per cent.
1900	..	..	..	..	47,257	47,257	139,265	33·9
1901	3,839	499	..	..	76,925	81,263	157,736	51·5
1902	1,975	5,360	..	..	68,819	76,154	144,325	52·7
1903	7,878	4,998	..	..	95,051	107,947	177,821	60·7
1904	10,323	8,559	..	..	66,142	85,024	150,190	56·6
1905	16,246	35,238	..	..	100,063	151,547	247,427	61·2
1906	102,260	96,017	7,486	..	146,117	351,880	571,495	61·5
1907	159,735	143,703	30,728	7,100	199,311	540,577	873,911	61·6

IV.—DESCRIPTION OF EXHIBITS.

The Mining Section was situated in the southern part of the Exhibition to the south of the motor car sheds, and just on the lower slopes of Sitabaldi Hill. It was administered by a committee composed of the following five gentlemen:—

R. H. Beckett, Nagpur; H. D. Coggan, Kamptee; J. Kellerschon, Nagpur; D. Laxminarayan, Kamptee; and Captian L. Ditmas, Chhindwara.

The exhibits can be divided into three sections:—

1. Collections of minerals.
2. Mining machinery.
3. The Laboratory (of the Victoria Technical Institute, Nagpur).

Of these, No. 3, the Laboratory, was arranged by Mr. R. H. Beckett, and being chemical and physical in its scope, will not be noticed here.

1. COLLECTIONS OF MINERALS.

The mineral collections were arranged in sheds 58 and 59, photographs of which are shown in plates i and ii respectively. These sheds were uniform in design with a considerable proportion of the Exhibition sheds, each of which consisted of a gable roof of galvanized iron supported by wooden posts; the inside arrangements consisted of shelves of bamboo laths along the centre, with a verandah on each side. Outside, the sheds were provided with Indo-Saracenic arches, with the spandrels decorated by Indian artists with scenes in colour from the great religious epics—the Mahabharata and the Ramayana. The illumination necessary at night was very effectively provided by electric glow lamps.

In general it may be said that although many of the exhibits were of a high order, many were disappointing, and, on the whole, the exhibits cannot be considered as having done due justice to the variety and value of the minerals of economic value found in this province. Some firms and individuals interested in mining did not exhibit at all, and others did not make as good a show as they could have done with the deposits at their command. Nevertheless, the nett result has been to bring many little known occurrences of minerals to the public notice, and to increase still more the public interest in this important phase of industrial activity.

Below is given a list of the mineral exhibits, with the exception of that shown by the Geological Survey of India. This (housed in shed No. 59) was a selection from the geological collections in the Geological Museum in Calcutta arranged under the following heads :—

1. Collection illustrating the minerals of economic value found in other parts of the Central Provinces, with the exception of coal.

2. Collection illustrating some of the more important of the minerals found in other parts of the Indian Empire that have not yet been found in the Central Provinces.

3. Collection illustrating the mineralogy and petrology of the manganese-ore deposits of India. This contained many rare and valuable specimens.

4. Collection illustrating the native iron smelting carried on in the Jubbulpore district.

5. Collection of maps, photographs, tables and diagrams, relating primarily to the Central Provinces, but also in some cases to other parts of India.

Detailed List of Mineral Collections in Shed No. 58 of the Mining Section.

1. *Great Indian Peninsula Railway, Mohpani Collieries, C.P.*

All the specimens are from Mohpani, Narsinghpur district, C.P.

Case containing: 5 Small Blocks of Coal from three different seams.
5 Trays with Nut-coal from same seams with complete analyses.
Map: Longitudinal Section showing strata of rocks and coal.

Two Large Blocks of Coal.

Case containing: Coal Fossils and Rocks associated with the coal.

Collection of Mr. F. L. G. Simpson.

2 Specimens Iron Stone from Clays at foot of Mahadevas.
2 do. Vindhyan Conglomerate Pebble from Mahadeva Conglomerate.
2 do. Vindhyan Jasper from Mahadevas.
1 do. Mahadeva Conglomerate.
1 do. Vindhyan Quartzite Pebble from Mahadeva Conglomerate.
1 do. Bedded Jasper from Mahadevas.
1 do. Banded Jasper from Mahadeva Conglomerate.
1 do. Drill Core of White Sandstone 253′ 9″ from surface.
1 do. do. do. Very soft white Sandstone 154′ from surface.
1 do. do. do. Fine Black Sandstone 155′ 9″ from surface.
1 do. do. do. Very dark grey streaky Sandstone 90′ 7″ from surface.
1 do. do. do. Grey Sandstone 95′ 8″ from surface and just below No. ¾ Seams.
1 do. do. do. Black streaky Sandstone 119′ 3″ from surface.
1 do. do. do. Coarse Grit 163′ 9″ from surface; from Mahadeva Clays.
1 do. do. do. Good Coal 85′ 3″ from surface (No. 2 Seam 26′ thick).
1 do. Altered Shale next trap dyke, No. 1 Seam.
3 do. Typical Talchir Grit with pebbles embedded.
2 do. do. do. Shale.

Specimens of Quartzite and Trap pebbles fr. the Talchir Grits.

1 Specimen Basalt Dyke 2′ wide, No. 2 Seam.

Fossils: 7 Specimens of *Glossopteris indica.*

2 do. of *Noeggerathiopsis Hislopi.*

2 do. of *Schizoneura Gondwanensis.*

1 do. of *Gangamopteris major.*

1 do. of *Neuropteris valida.*

1 do. of Equisetaceous stem.

An example of folded leaf of (?) *Neoggerathiopsis Hislopi.*

2. *J. Kellerschon, Nagpur.*

Case containing Specimens; all from Agargaon, Nagpur District, C.P.

4 Specimens (nuggets) of Wolframite.

1 Large Specimen of Wolframite weighing about 12 lbs.

1 do do of Quartz with numerous broken crystals and fragments of wolfram imbedded.

2 Trimmed Hand Specimens of Quartz showing Wolframite.

2 do. do. do. of Mica-Schist.

1 Specimen of Mica-Schist showing peculiar staining.

2 Trimmed Hand Specimens of Mica-Quartz-Schist.

1 do. do. Specimen of Tourmaline-Schist and Mica-Schist.

1 Tray with dressed Wolframite Ore.

2 Trays showing crude ore and concentrates, with analyses of each.

1 Tray with Magnetite and Complete Analysis.

Two large specimens of Quartz with Wolframite imbedded, from Agargaon.

Case containing: 25 Specimens of Manganese Ore collected from Nagpur, Bhandara, Balaghat, Chhindwara, and Jubbulpore Districts, with 11 Analyses.

7 Specimens of Rock associated with above ores.

1 Specimen Manganiferous Hematite from Mansakra, Jubbulpore District, and Analysis.

1 do. Hematite-Jasper, Mansakra Mine, Jubbulpore District.

1 do. Micaceous-Iron-Banded-Quartzite, Ghogra, Jubbulpore District.

1 do. Hematite Ore, Lohara, Drug District, and Analysis.

1 Specimen Bauxite, Katni, Jubbulpore District, and Analysis.
1 do. Steatite, Marble Rocks, Bhera Ghat, Jubbulpore District, and Analysis.
1 do. Marble, Marble Rocks, Bhera Ghat, Jubbulpore District, and Analysis.
1 do. Limestone, Balaghat District, and Analysis.
1 do. Muscovite Mica, Bhandara District.
1 do. Staurolite, Matura, Bhandara District.
1 do. Wolframite in Quartz, Agargaon, Nagpur District.
1 do. Copper Ore, Sleemanabad Mine, Jubbulpore District, and Analysis.
1 do. Dolomite ("country" of above), Sleemanabad Mine, Jubbulpore District.
1 do. Quartz-Porphyry Dike Rock, Sleemanabad Mine, Jubbulpore District.
1 do. Barytes, Sleemanabad, Jubbulpore District, and Analysis.

Two pieces of Ferro-Manganese produced from Manganese Ores of the C.P.

One piece of Spiegeleisen produced from Manganese Ores of the C.P.

One Specimen of Stalactitic Chalcedony, Telenkhari, Nagpur District.

One Gold Washing Pan for concentrating ores.

One Jackson Hand Power Rock Drill (see special note, page 147).

3. *Central India Mining Co., Ltd., Kamptee.*

Case containing Specimens: all from Pali, Nagpur District, C.P.

42 Specimens Pyrolusite cleaned for export with complete Analysis.
2 Specimens Undressed Pyrolusite.
2 do. Pyrolusite, dense, mixed with crystalline.
1 do. do. radiate.
1 do. do. dense.
1 do. do. concentric-structured.
2 do. Concentric-structured Manganese Ore of Psilomelane and Pyrolusite.
2 do. Quartz, finely crystalline, stalactitic.
1 do. Chalcedony Geode with lining of Quartz.
1 do. Chalcedony, banded.
5 do. Quartz, cellular with pyramidal impressions.

7 Specimens Crystalline Quartz growing on Pyrolusite.

9 do. Geodes, composed of concentric layers of crystalline Quartz, Agate, and Pyrolusite.

1 do. Tourmaline-Pegmatite intrusive in the Limestone of Pali Mine.

5 do. Crystalline Limestone (Marble) forming the "Country" of the Pali Pyrolusite.

Two Large Specimens of Pyrolusite, undressed, Pali Mine, Nagpur District.

Two Specimens of Mica-Quartz-Schist, the "Country" of Mandri Mine, Nagpur District.

Five do. Rhodonite from Manegaon Mine, NagpurDistrict.

Five do. Manganese Ore, Manegaon Mine, Nagpur District, with Analysis.

One do. do. do. Kacharwahi Mine, Nagpur District, with Analysis.

One do. do. do. Mansar Mine, Nagpur District, with Analysis.

One do. do. do. Parsoda Mine, Nagpur District, with Analysis.

One do. do. do. Mandri Mine, Nagpur District, with Analysis.

Two do. do. do. Miragpur Mine, Bhandara District, with Analysis.

One do. do. do. Kosumbah Mine, Bhandara District, with Analysis.

Three do. do. do. Sukli Mine, Bhandara District, with Analysis.

3 Large Photographs showing Pali Mine, Nagpur District.

1 Large Photo showing Mine Quarry and Tramway.

2 Large Photos of Bridges on the Light Railway (Tumsar Line).

2 Frames containing a number of views of Mines, Light Railway, Loading on the Bengal-Nagpur Ry., and at Bombay Harbour.

4. *P. C. Dutt, Jubbulpore.*

Case containing Specimens; all from the Jubbulpore District, C.P.

3 Specimens of Agate (Chalcedony), Water Works, Jubbulpore.

1 do. Amethyst on Agate, Water Works, Jubbulpore.

3 do. Barytes with Analysis, Sleemanabad Mine.

1 do. Iron Capping of Sleemanabad Mine.

1 Specimen of Malachite and Azurite with Analysis, Sleemanabad Mine.

1 do. Malachite in Quartz with Analysis, Dharwara.

1 do. Chalcopyrite with Malachite in Quartz, Sleemanabad Mine.

1 do. Copper Pyrites with Analysis, Sleemanabad Mine.

1 do. Peacock Ore (Chalcopyrite) in Dolomite, Sleemanabad.

1 do. Copper Pyrites (Chalcopyrite) and Grey Copper Ore (Tetrahedrite) in Dolomite, Sleemanabad.

1 do. Chalcopyrite, Sleemanabad Mine.

1 do. Chalcopyrite and Tetrahedrite with quartzose gangue, with Analysis, Sleemanabad.

1 do. Quartz-Porphyry Dyke-rock, Sleemanabad.

1 do. Dolomite with Quartz Veins, Sleemanabad.

1 do. Graphite with Analysis, no locality given (confidential).

1 do. Micaceous Hematite, Agaria.

1 do. Banded Hematite-Jasper, Sihora.

1 do. Red Jasper, Salaia near Sleemanabad.

1 do. Galena with Analysis, Sleemanabad.

1 do. Siliceous Limestone, Sleemanabad.

2 do. Lower Vindhyan Limestone, Dunn's Quarry, Katni.

1 do. Manganese Ore, Darshani near Sihora.

One Tray with Fuller's Earth, Tikari, Jubbulpore District, with Analysis.

One Tray with White Clay with Analysis, Tikari.

One Bag Red Ochre, Jauli.

One Bag Yellow Ochre, Sihora Tahsil.

Three Blocks White Soapstone with Analysis, Marble Rocks.

Three Blocks Pink Soapstone with Analysis, Marble Rocks.

Two Blocks Yellowish Soapstone with Analysis, Marble Rocks.

1 Specimen of Rock Crystal.

Four Specimens Lean Copper Ore, Sleemanabad Mine.

Two Specimens Chalcopyrite, Tetrahedrite and Iron Pyrites in quartzose gangue, Sleemanabad Mine.

One Specimen Tetrahedrite with Analysis, Sleemanabad Mine.

Two Specimens Reddish Pisolitic Bauxite with Analysis, Tikari.

One Specimen Grey Pisolitic Bauxite with Analysis, Tikari.

One do. do. Bauxite with Analysis, Tikari.

5. *Central Provinces Prospecting Syndicate, Ltd., Kamptee.*

Case containing Specimens; all from Lohdongri Mine, Nagpur District, C P.

17	Specimens	of Manganese Ore of various structures, from coarse crystalline to fine and dense.
2	do	of Manganese Ore slickensided.
43	do.	of Braunite showing crystals of various sizes in various grouping.
16	do.	of Manganese Ore of mammillary and radiating structure.
5	do.	of Spessartite Crystals grouped.
4	do.	of Tourmaline Crystals.
1	do.	of Finely-Crystalline Braunite in matrix of Psilomelane.

Several pieces of soft and specular Iron Ore.

One large Block of Manganese Ore.

A number of the above specimens are accompanied by Analyses.

6. *S. C. Harris, Ukua, Balaghat District, C.P.*

Case containing Specimens; all from Ukua Group of Mines, Ukua, Balaghat District, C.P.

6	Specimens	Manganese Ore (Braunite and Psilomelane) with Analyses.		
1	do.	do.	do.	slaty porous with analysis.
1	do.	do.	do.	slaty dense with analysis.
1	do.	do.	do.	cellular structure with analysis.
1	do.	do.	do.	coarse crystalline, mainly Braunite, and showing pure quartz cemented to it. Analysis.
2	do.	do.	do.	banded with siliceous layers.
1	do.	Manganiferous Quartzite coated with thin layer of Manganese Ore.		
1	do.	Quartzose Lean Manganese Ore forming cap rock of deposit.		
1	do.	Highly Siliceous Manganese Ore from Tipagarh Forest.		
1	do.	Phyllite, fine-grained, part of Hanging Wall.		
1	do.	Mica-Quartz-Phyllite, part of Foot Wall.		
1	do.	Micaceous Slaty Quartzite, associated with the ores of Ukua deposit.		

One framed Map showing Ukua concession and all outcrops of Manganese Ore along the trend of about 3 miles, also the varying dips and two cross sections.

7. *D. Laxminarayan, Kamptee.*

Case containing:

1	Specimen	Manganese Ore,	Government Forest No. 28, Bhandara District.
1	do.	do.	Asalpani Mine, Bhandara District.
2	do.	do.	Kurmura Mine, Bhandara District.
1	do.	do.	Chaukhandi Mine, Balaghat District.
1	do.	do.	Garraghat Mine, Balaghat District.
1	do.	do.	Chikmara Mine, Balaghat District.
2	do.	do.	Jamrapani Mine, Balaghat District.
3	do.	do.	Kandri Mine, Nagpur District.
1	do.	do.	Seomara Mine, NagpurDistrict.

All the above with analyses.

Four Large Blocks of Manganese Ore, Thirori Mine, Balaghat District, with Analysis.

One frame with views of Thirori Mine.

Do. do. Jamrapani Mine.

8. *Byramjee Pestonjee & Co., Nagpur.*

Case containing:

1	Specimen of	Tourmaline, Ansera, Bhandara District.
1	do.	Pyrolusite, Pali Mine, Nagpur District.
1	do.	Tourmaline, Katangi, Balaghat District.
2	do.	Copper Pyrites, Sleemanabad, Jubbulpore District.
1	do.	Steatite, Marble Rocks, Jubbulpore District.
1	do.	Asbestos, Toomkedu, (? Tumkhera, Bhandara District).
1	do.	Galena, Khairagarh State, Drug District.
1	do.	Do. Khariar Zemindari, Raipur District.
1	do.	Geode of Grey Quartz and Pyrolusite, Pali Mine, Nagpur District.
1	do.	Copper Pyrites, Kochewahi, Balaghat District.
1	do.	Wolframite, Agargaon Mine, Nagpur District.

1 Specimen of Graphite, Lawada, Balaghat District.
1 do. do. Khariar Zemindari, Raipur District.
1 do. Asbestos, Khairagarh State, Drug District.
Tray with Garnets from River Bed adjoining Khariar State, Raipur District.
Do. Gold Sand from Sona River, Balaghat District.

Four Specimens of Manganese Ore, Bharweli Mine, Balaghat District.

One Specimen of Manganese Ore, Kandri Mine, Nagpur District.

9. *D. Ware (with Shaw, Wallace & Co.)*

Ten Specimens of Trap Rock containing Coal, Jinji, Nagpur District.

Group of Specimens of Fossils:

Glossopteris indica
Gangamopteris Cyclopteroides
Sphenozamites
Phyllotheca indica

obtained from coal-bearing, coloured sandstone strata of Upper Damuda age immediately overlying, but unconformable to, the Barakars, and known at present at the "Moturs." Fossils were obtained from the Coal Measures of Pench Valley and identified by the Geological Department at Calcutta.

10. *Agricultural Chemist of C. P. and Berar.*

Seven small baskets containing Salts from Lonar Lake.

Analysis shows composition to be Chlorides, Carbonates, and Bi-Carbonates of Soda.

11. *Dewan of Korea State, C.P.*

One Specimen of Coal, Korea.

12. *Secretary of Municipal Committee, Bhandara, C.P.*

One Specimen of Staurolite, Matura, Bhandara District.

13. *Ram Rao Vishwanath Taksal, Bilaspur.*

Specimens of Coal.	All from Bilaspur.
Limonite.	
Laterite.	
Rock Crystals.	

14. *R. B. Indrajsingh, Zemindar, Kamtha, Bhandara District.*

    Specimens of Hematite (very siliceous).

15. *G. S. Pranjpe, Kolhapur.*

    Seven Slates and Pencils } Kolhapur.
    Two Slabs of Slate before cutting. } Kolhapur.

16. *Mukarjee Sirvya, Saugor, C.P.*

    Bag and Box with Red Ochre, Saugor.

17. *Sataram Luxman & Son, Shahabad, Deccan.*

    Two Limestone Flagstones.

18. *Ganpat Rao Shikhande, Saugor, C.P.*

    Specimens of Red Ochre, Copper Ore, Calcite, and several other specimens not determined.

19. *H. L. Palmer, Chanda, C.P.*

    Specimens of Argillaceous-Ochreous Rocks, Chanda.
    Concretionery Nodules of Sandstone, Chanda.
    Well Curb of native make, ancient.

20. *Laxmi Ink Factory, Bellary, Madras.*

    Specimens of Limestone (Calcareous Tufa). } Bellary, Madras.
    Red Ochre. } Bellary, Madras.
    Road Metal (Pebbles). } Bellary, Madras.

21. *Sonu Jharu, Tiju Dhekal, and Khora Jharu goldwashers from Lodangi, Pipalgaon, Lanji Thana, Balaghat District.*

    Gold-bearing Sand from Sona Nadi, Balaghat District. See also page 147.

22. *Gwalior State, C.I.*

    Four Sample Blocks of Stone from different quarries of Gwalior State.

In Shed 59.

23. *Geological Survey of India.*

    Collection referred to on page 123.

24. *W. J. Considine, Bilaspur.*

    Limestone Flagstones for Floors and Roofing, from Sikosa, Bilaspur District.

Certain of the exhibits given in the foregoing list are of sufficient interest to merit special notice. Many of them were illustrated by means of analyses, a large number of which referred to manganese-ore. Most of the latter are not published here, because abundance of information concerning the C.P. manganese-ores has now become available elsewhere.[1] Some of the other analyses, however, are thought to be of sufficient interest to merit reproduction, and are given below with the notes on the exhibits.

1. *Great Indian Peninsular Railway Company's Mohpani Colliery.*—The exhibit comprised samples of coal from the different seams with both proximate and ultimate analyses, a diagrammatic cross-section of the mine, and a collection of rocks and fossils. Amongst the fossils were several specimens that have been provisionally determined as *Noeggerathiopsis Hislopi*[2]; of which one seemed to be a folded leaf. The proximate analyses (carried out in the laboratory of the Geologica' Survey of India) and the ultimate analyses (by Mr. C. S. Fawcitt, of Bangalore), with a complete analysis of ash (also by Mr. Fawcitt), are given below:—

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[1] L. L. Fermor, *Mem. Geol. Surv. Ind.*, XXXVII (1909).

[2] By Babu Bankim Bihari Gupta, Museum Assistant, Geological Survey of India.

Proximate Analyses and Calorific Values of Mohpani Coals by the Geological Survey of India.

No. of Seam.	Moisture.	Volatile matter.	Fixed Carbon.	Ash.	Sulphur.	Calorific value. Calories.	Evaporative value—lbs.	Colour of Ash.	Caking properties.	REMARKS.
No. 1.—Top Seam ..	4·06	30·80	51·05	14·09	0·79	7,187	13·38	Light grey	Cakes, but not strongly.	
No. 1.—Bottom Seam	4·15	27·52	49·87	18·46	0·43	6,600	12·29	White ..	Do.	
No. 2 Seam ..	4·40	30·94	51·60	13·06	0·44	7,187	13·38	Very light grey.	Cakes, but not very strongly.	
No. 3 Seam ..	5·88	31·30	53·03	9·79	0·31	6,600	12·29	Nearly white	Do. ..	Sample obtained in a wet winning driving; no average sample being obtainable at the time in this seam.
No. 4 Seam ..	5·89	25·65	48·70	19·76	0·23	5,867	10·93	Light greyish white.	Cakes, but not strongly.	Sample obtained by sinking underfoot in a wet road; no average sample being obtainable at the time in this seam.
No. 1 Seam.—Splint coal specially adapted for lime burning.	3·68	23·06	31·94	41·32	0·85	4,400	8·19	Light buff	Does not cake, but sinters slightly.	

Ultimate Analyses and Coke Assays by Mr. C. S. Fawcitt, of Bangalore.

Number of Seam.	Ultimate Analysis.							Coke Assay.		
	Total Carbon.	Hydrogen.	Oxygen.	Nitrogen.	Sulphur.	Ash.	Moisture.	Coke.	Volatile matter.	Moisture.
No. 1 Bottom Seam	62·01	3·86	9·06	0·81	0·44	20·03	3 79	68·88	27·33	3·79
,, 2 Seam ..	65·09	4·17	11 92	0·88	0·47	12·22	5·25	63·80	30·95	5·25
,, 3 ,, ..	70·14	4·66	9·45	0·91	0·41	11·05	3·38	66·45	30·17	3·38
,, 4 ,, ..	60·93	3·69	9·11	0·78	0·33	19·24	5·92	68·48	25·60	59·2
No. 1, Splint coal for lime burning ..	45·01	3·62	7·61	0·78	0·98	41·85	0·15	77·50	22·35	0·15

Remarks:—For Nos. 3 and 4 Seams, same as in previous set of analyses.

Complete Analysis of Ash from No. 1 Bottom Seam,—by Mr. C. S. Fawcitt.

Ferric oxide	1·12
Ferrous oxide	*nil*
Alumina	29·91
Manganese oxides	*trace*
Lime	1·36
Magnesia	1·01
Baryta	0·03
Potash and Soda	*trace*
Silica	66·31
Sulphuric oxide	0·27
Phosphoric oxide	0·004
	100·014

2. *J. Kellerschon*.—This included a fine crystallized specimen of staurolite in fine-grained sericite-quartz-schist from Matura, Bhandara district; but perhaps the most noteworthy part of the collection was the series of speci-

mens of wolfram from Agargaon in the Nagpur district, accompanied by analyses. There was also a good specimen of the quartz-porphyry found at Sleemanabad in association with the copper deposits.

The following analyses of wolfram from Agargaon, and of magnetite found near by, were made for Mr. Kellerschon by Mr. J. M. Camp, in the laboratory of the Duquesne Steel Works and Furnaces, Pa., U.S.A.

Wolframite (Nuggets).

Tungsten	51·59	= 65·05 tungstic oxide (WO_3)
Silica	3·40	
Iron	14·50	
Manganese	2·94	
Phosphorus	0·018	

Wolfram-bearing Quartz.

	Crude Ore.	Concentrates.
Iron	9·08	13·01
Manganese	1·20	1·85
Phosphorus	0·232	0·075
Silica	37·50	7·37
Tungstic oxide	42·60	66·48

Magnetite (North Belt).

FeO	27·06	Iron = 68·25 (FeO and Fe_2O_3)
Fe_2O_3	67·45	
Al_2O_3	2·36	
MnO	0·13	Manganese = 0·10
CaO	0·00	
MgO	0·10	

SiO_2	1·80	Silica = 1·80
TiO_2	0·75	
P_2O_5	0·02	Phosphorus = 0·01
Combined water not det. .	..	
Total .	99·67	

3. *Central India Mining Company, Ltd.*—The feature of this collection was a beautiful series of geodic specimens from the Pali pyrolusite quarry in the Nagpur district. Many of these geodes showed concentric layers of chalcedony, agate, and pyrolusite, with well-crystallized quartz forming the innermost lining. The following is a complete analysis of a picked piece of pyrolusite.

Páli Pyrolusite.

Manganese peroxide . .	93·05	61·40 % Mn.
Manganese protoxide . .	3·13	
Ferric oxide	0·11	0·06 % Fe.
Alumina	0·45	
Baryta	0·65	
Lime	0·53	
Magnesia	0·24	
Silica	1·10	
Sulphur	0·052	
Phosphoric oxide . . .	0·020	0·009 % P.
Arsenic oxide	traces	
Cupric oxide	0·081	
Lead oxide	0·027	
Zinc oxide	0·087	
Combined water and organic matter	0·20	
Carbon dioxide . . .	0·12	
	99·847	

4. *P. C. Dutt.*—The chief features of this collection, all the specimens of which came from the Jubbulpore district, thus incidentally drawing attention to the variety of valuable minerals found in this district, were the series of specimens from the Sleemanabad copper mine, and the masses of bauxite from Tikari near Katni. The collection was illustrated by a series of analyses some of which are given below. Some of them show evidence of being only approximate. These analyses show that the yellowish and pinkish colours denote increasing amounts of iron oxide.

Soapstone from the Marble Rocks.

	White.	Yellowish.	Pink.
Magnesia	31·54	30·17	30·80
Silica..	62·29	63·14	61·71
Iron oxide	Trace	1·56	1·72
Water	5·80	5·01	5·17

The two following analyses were made by Messrs. Maret Delatire and Maris of Paris:—

Bauxite from Tikari.

Alumina	59·78	62·05
Ferric oxide	2·20	5·87
Silica	1·58	0·72
Titanic oxide	8·22	10·88
Loss on heating	28·10	20·43
Undetermined	0·12	0·05
	100·00	100·00

Most of the following analyses were made by Dr. Schulten of Calcutta:—

Clays from Tikari.

	Fuller's earth.	White clay.
Silica	51·70	44·81
Alumina	9·47	42·22
Ferric oxide	10·60	..
Water	..	12·35

Copper-ores from Sleemanabad.

	Locality.	Copper.	Silver. per ton.			Gold. per ton.		
		Per cent.	Oz.	Dwts.	Gr.	Oz.	Dwts.	Gr.
Malachite in quartz	Dharwara.	2·00	—	4	21	Traces.		
Malachite and azurite.	Sleemanabad.	10·39	16	5	—	—	11	10
Copper pyrites ..	Do.	4·00	10	—	—	Traces.		
	Eric shaft, 100 ft. depth.	..						
Grey copper ore (Tetrahedrite).	Sleemanabad.	11·83	42	2	19	—	3	6

Chalcopyrite and Tetrahedrite, with quartzose gangue—Sleemanabad.

	Per cent.	oz.	dwts.	gr.
Copper	19·10			
Arsenic	2·17			
Antimony	1·82			
Zinc	1·28			
Silver per ton		85	13	8
Gold per ton		—	14	16

Galena—Sleemanabad.

	Per cent.		
Lead	29·00		
		oz. dwts. gr.	
Silver per ton		2 9 —	
Gold per ton		*nil.*	

Red Ochre—Jauli.

	Per cent.
Iron	52·98
Manganese	0·21
Insoluble residue	23·00
Phosphorus	0·04

5. *Central Provinces Prospecting Syndicate, Ltd.*—This collection, by far the most interesting of all to the crystallographer, was the result of assiduous collection by Mr. E. L. Young at the Lohdongri manganese mine when he was in charge of it. At this mine well-crystallized specimens of braunite are by no means abundant; but Mr. Young has collected a very fine series showing many well-developed crystals.

6. *S. C. Harris.*—This was a neatly-got-up collection illustrating well the characters of a manganese deposit, Ukua, that does not lend itself to much mineralogical display.

7. *D. Laxminarayan.*—This consisted of large masses of manganese-ores with analyses and photographs of mines. Two new localities for manganese-ore in the Nagpur District—Tangla and Seomara—are given. The analyses given for ores from these localities are :—

	Tangla.	Seomara.
Manganese	50·27	50·35
Silica	5·77	5·27
Phosphorus	0·68	0·67

8. *Byramjee Pestonjee & Co.*—The most interesting specimen shown was a geode from ground at Pali adjoining that worked by the Central India Mining Company. The beauty of the specimen lay in the delicate grey tint of the quartz crystals lining the inside of the geode. Several of the specimens shown come from localities that are probably new, namely the two galena specimens, the copper pyrites of Kochewahi and the two graphite specimens.

24. *W. J. Considine.*—Not only were slabs of the Sikosa flagstones from Sikosa in the Bilaspur district exhibited, but a practical demonstration of the use of this stone was given by flooring the whole of the verandah on one side of one of the Mining sheds. The stone is a dark-coloured limestone.

For collections of minerals awards were made under two headings, as follows:—

(*a*) For the best collection from any one mine in the possession of exhibitor or his employers, illustrating the nature of the ores, mode of occurrence, surrounding rocks, special forms of minerals, etc.

(*b*) For the best prospecting collection made within the Central Provinces and Berar; extra points to be given for specimens accompanied by analyses.

In making the awards the collections exhibited by the Geological Survey of India were not regarded as entering into the competition; Mr. Considine's exhibit, also, was not regarded as coming within the scope of either of the awards. Special awards were made to each of these exhibitors.

The following is a list of the awards:—

	Award.	Exhibitor.	Exhibit.
a. Best collection from any one mine.	Gold Medal.	Great Indian Peninsular Railway.	Collection from Mohpani Colliery.
	Silver Medal.	Central Provinces Prospecting Syndicate.	Collection from Lohdongri Manganese Mine.
	Silver Medal.	Central India Mining Co.	Collection from Pali Manganese Mine.
	Bronze Medal.	S. C. Harris.	Collection from Ukua Manganese Mine.
b. Best collection from the C.P.	Gold Medal.	J. Kellerschon	General Collection.
	Silver Medal.	P. C. Dutt.	do.
c. Special Awards.	Gold Medal.	Geological Survey of India.	Collection illustrating minerals of the C.P.
	Silver Medal.	W. J. Considine.	Sikosa flagstone.

2. MINING MACHINERY.

A large collection of mining appliances and machinery was exhibited by Messrs. Burn & Co. in a special shed (No. 61), whilst Messrs. Orenstein and Koppel had a special shed for their mining railway exhibits. The Ingersoll-Rand Co.'s drilling appliances were shown out in the open, and the remainder of the mining machinery exhibits housed with the mineral collections.

Lists of the exhibits are given below in sufficiently detailed form to obviate the necessity of further explanation or description. Special attention may be directed, however, to the exhibit by three Indian sonjharias or gold-washers of the way in which they make a livelihood out of washing auriferous sands in the Balaghat district. After concentrating the gold by panning into a small bulk mixed with magnetite they finally recover the gold by amalgamation, followed by retorting.

Detailed List of Mining Machinery.

25. *Burn & Co., Howrah, Raniganj and Jubbulpore.*

A Hoisting Engine, Single Drum. Set of Boring Tools. 4″ internal diameter. Three Winches, 2, 6, and 12 tons, respectively. Pulsometer Pumps. Coal Tubs. Haulage Clips. Safety Hooks for Cages. Mine Signal Bells. Pulley Blocks for Ropes. Miner's Wedges, Hammers, Picks, Kodalis, Shovels, etc.

The Hoisting Engine, 9′ by 18′, is equipped with powerful beam-brakes of very effective type. The steam stop-valve is of the equilibrium type, very easily opened or closed, and quick in action. The engine is built specially to meet the demands of Indian Collieries.

The Boring Tools are for depths of from 100 to 150 feet and are similar to those approved of by Mr. Alfred Chatterton, Director of Technical and Industrial Enquiries, Madras. They are extra strong, easily manipulated and specially made to suit Indian labour. The tubes are known as the swelled and cressed joints.

The Coal Tubs are of a very simple design with an underframe of wood, and sheet-iron sides stiffened up. A cheap and serviceable tub.

26. *Orenstein and Koppel, Calcutta.*

Four-wheel Coupled Tank Locomotive, 30 H.P., Gauge 24″. Coal Wagon with hinged side-doors. Mining Wagon with timber frame and steel box. Scoop All-round Tipping Wagon. Tipping Wagon with patent fastener. Mining Wagon with 2 trunnions and a latch. Tipping Wagon with outside axle boxes and screw brake. Motor Trolley.

The Locomotive on exhibition was taken from the Light Railway built by the Central India Mining Company connecting Tumsar Railway Station with some of their Manganese Mines. It has been in use for the past three years and so far shows no apparent signs of wear. An advantage of this type of engine is the easy access to all the moving parts for inspection, cleaning, and oiling. As narrow-gauge railways generally allow of sharp curves they are highly desirable for haulage of moderate quantities, thus acting as feeders for the main trunk lines.

The Coal Wagon with hinge doors on both sides allows an easy discharge and thus effects a saving of labour.

The Tipping Wagons have the usual tipping gear with automatic fastener and bulb iron rim on body. The one tipping on two trunnions at each end is held in travelling position by a latch. All are of standard recognised make. The automatic fastener prevents tipping while travelling, but can instantly be tipped by dropping one lever only, with no possibility of injury to workmen, as the body can only tip to the side opposite the attendant.

Photos and models of the various types of wagons, trollies, etc., made by this company were also shown.

27. Nobel's Explosives Co., Limited, Glasgow.

Ewart Latham & Co., Bombay, Agents.

A Model illustrating Section of part of a Coal Mine and in it position of boreholes charged, with facsimiles of Cartridges and Electric Detonators inserted. Also the way the wiring and connection is made with the 'Leading Wire' or cable which is to be connected with the Electric Battery for firing.

Two Nobel's 'Twist' Exploders (for High and Low Tension) for exploding detonators. Two Electric Cables connected with the Exploders.

Two Reel Boxes for the two coils of Electric Cables.

An Almirah containing: Models of Nobel Explosives manufactured in accordance with British Government Regulations, such as Dynamite (red), Blasting Gelatine, No. 1 Gelatine-Dynamite, Gelignite, Carbonite, Saxonite, Monobel powder. Also Detonators, Electric Detonator Fuses, and Safety Fuses. Facsimiles of all explosives produced by the Company for Railway and Dock Construction, Metalliferous and Coal Mining; also for Military and Submarine Mining. Batteries for Electric Detonators and other Appliances. Water Cartridges (Settle's Patent) for Safety Blasting, Magazine Appliances. Two Tin Packets showing method of packing detonators. Facsimiles of detonators and fuses showing position on a cartridge ready for explosion.

A Case containing: 3 Coils Samples of Safety Fuses. Models of Cartridges and Blocks of Dynamite, Gelatine-Dynamite, Gelignite, Blasting Gelatine, and Saxonite, showing appearance and condition of the explosives when in frozen and unfrozen state.

Photographs, Literature, etc.

28. *Ingersoll-Rand Co., London.*

Jacomb Hood & Co., Calcutta, Agents.

Ordinary Air (or Steam) Rock Drill (Baby) and Columns for Mounting.

Electric Air Rock Drill.

Coal-cutting Machine (Puncher).

Pneumatic Plug Drill (Hammer).

The *Ingersoll 'Baby' Drill* is a favourite for working granite, marble or limestone quarries, for plug holes; lofting and capping, or the stone yards for drilling bolt holes. When mounted on a quarry bar or tripod it will put down more hole in a given time than any known means of rock drilling.

The *Electric Air Drill* (Temple-Ingersoll) is exactly what the name implies, an air drill distinctly, the operating power of which is electricity. The drill consists of a complete device pulsator, hose lines and drill, making a closed circuit in which the same air is repeatedly compressed and expanded. *Operation.*—One hose connects one pulsator cylinder to one end of the drill cylinder, a similar hose connecting the other end of the drill cylinder to the other pulsator cylinder. Through these two hose lines alternately impulses of air under pressure of 30—40 pounds are communicated to the drill piston. One impulse throws the piston forward, the other throws it back. For every revolution of the pulsator shaft there is a blow and a return of the drill piston. *Features* :—1. No jacket is required on the pulsator cylinder, the expansion of the air counteracting the heat of compression. There being no exhaust the Electric Air Drill cannot 'freeze up.' 2. No valve movements. 3. Easily handled. 4. A very hard blow. The drill on exhibition is designed for use in mine headings, development work, drilling medium-sized holes in mine, quarry, tunnel or contract excavations. It has a drilling capacity equal to the standard 2½ inch 'Sergeant' drill and is intended for just such work as this latter machine is ordinarily used for. It will easily drill holes up to a depth of 8 feet and of a diameter from 1—1½ inches. The weight of this drill is 192 lbs.

Coal Cutter.—Known to the mining world as the Puncher; is a substitute for the old system of a man with a hand-pick. It is capable of undercutting from 5—15 times as much as one man. A compact, durable and efficient labor-saver, meeting with remarkable success.

Pneumatic Plug Drill or Hammer.—A new design carrying with it unique advantages without departing from the ordinary method of operations. The Plug Hammer is used for drilling stone or granite, but also for holes used in mine blasting. It has a larger capacity for work than any other hammer of the same size, and this is due to the quality of the blow, the use of hardened surfaces, and also to the direct air admission and exhaust ports, which insure the full force of the air pressure on the piston from beginning to end of stroke and the highest velocity of the striking piston.

Columns for Mounting Rock Drills.—These columns are simply round, extra heavy, wrought steel tubes with a suitable claw-foot on one end and either one or two clamping or jack-screws on the other. The column is set up and the screw run out, thus jacking the column between the floor and the ceiling, or between opposite sides of the tunnel. In tunnels of large section the double screw column is always employed with one or two swinging arms on which the drills are mounted by a special clamp.

29. *Jackson Hand Power Rock Drill.*

The drill on exhibition is manufactured by the Jackson Drill and Manufacturing Co. of New York, U.S.A. The drill is equipped with the ordinary hand feed, and the interior mechanism consists of but two moving pieces, a ram with collars of one solid steel forging, and a cam axle and cams, also of a single steel forging. A power spring of the best spring steel is used. *Operation.*—The drill is operated by a rotary movement of hand crank, which, because of the momentum imparted to small fly wheels, may be turned slowly and evenly, the operator experiencing no jar or shock whatever. It can be operated by two men if desired, using a crank on each side. The drill delivers $3\frac{1}{4}$ strokes for each revolution of the crank, or from 180 to 250 per minute. The ram rotates automatically during its backward movement only, preventing bits from being ground and dulled by rotating when in contact with rock. It may be employed in mining, tunnelling, sinking, and stoping, for all kinds of quarry and surface stone work, and, operated by two men, will do as much as five or six men using hammers. The daily work developed by a man hammering is about 480,000 feet pounds, while turning a crank a man developes 1,300,000 foot pounds. It follows that the turning of a crank is a better way of utilizing a man's strength than by direct hammering.

30. *R. Oates, Umaria.*

Automatic Haulage Clip.—As shown at the exhibition seems to be a device about the merits of which little can be said, as its action is shown on a very small model. It is no doubt an ingenious device, but whether superior to any of the haulage clips now in use only future application under trying circumstances in mines will show.

31. *Sonu Jharu, Tiju Dhekal, and Khora Jharu; Sonjharias from Lodangi near Pipalgaon, Lanji Thana, Balaghat district, C.P.*

Wooden Gold Washing Pans.—A very interesting exhibition of gold concentration by hand-panning was given by these sonjharias, who use their crude implements with such skill as to put to shame the more civilised explorers of such countries as South Africa and Australia.

The following awards were made for mining machinery :—

	Award.	Exhibitor.
Drilling machinery ..	Gold medal ..	Ingersoll-Rand Co.
Explosives ..	Gold medal ..	Nobel's Explosive Co.
Concentrating machinery.	Bronze medal and Rs. 10 to each.	Sonu Jhara, Tiju Dhekal, and Khora Jhara—gold-washers.

The exhibits of Messrs. Burn & Co. and of Orenstein and Koppel, although noticed above, were not exhibited with the mining machinery.

C. P. and Berar Exhibition, 1908; Mining Section, Shed 58.

Photo. by Shalom, Kamptee.

C. P. and Berar Exhibition, 1908; Mining Section, Shed 59.

Notes on the Waters of Bikanir.

BY

W. H. Pickering.

The writer is able to offer nothing better than a few facts and tentative theories based upon them. The facts were gathered during a short visit to Rajputana when other duties prevented much time being given to the subject of the water which flows under Bikanir. The writer thinks, however, that the few observations he was able to make should be brought under the notice of the members of this Institute. He hopes that they will be supplemented in discussion, and that eventually considerable information will be recorded about what is a very important and interesting question.

If a stranger were to stand on the walls of Bikanir during the hot weather and look across the sandy desert which surrounds it, and if he had studied the map and the rainfall records, he would be lost in amazement that so large a town should exist and flourish in what is "a dry and thirsty land where no water is" for the greater part of the year. The rainfall at Bikanir has averaged 7 inches for the past ten years. His first question would be. How can this large population be supplied with water ? The answer is that an unfailing supply of water is found about 300 feet below the surface. The writer was able to get within touch of this water at one of the deepest wells in Bikanir town and also at Palana about 14 miles to the west where the water-bearing strata have been pierced to the greatest depth. At Palana a seam of lignite in the Lower Eocene is being worked. The coal is found at a depth of 235 feet from the surface, but as no mine can exist without water, one of the shafts was sunk to the water-bearing strata 90 feet below, and powerful pumps fixed in a drift above the water-level. The writer was able to observe the water and water-bearing strata by having the water pumped out

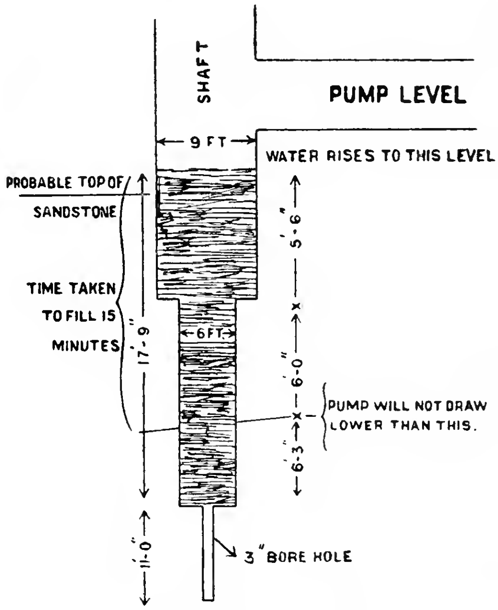

FIG. 1.

and then going down into the sump. The strata consist of coarse open-grained sandstones apparently of great thickness. They have been pierced to a depth of 28 feet 10 inches (17 feet 9 inches shaft and 11 feet 0 inch bore-hole). The water rose so quickly in the sump that observations had to be very hurriedly made. The lining of the shaft prevented an accurate examination of the strata, but the fact that the water is in a sandstone under impervious clay was established. The issue of water was estimated by the writer at the time to be 20,000 gallons a minute. The manager, Mr. W. H. Phillips, afterwards had the sump cleaned out and very kindly furnished the information given in the opposite sketch (fig. 1).

From this sketch it will be seen that the time taken to fill 520 cubic feet was 15 minutes. This works out at 13,000 gallons an hour ; and as the flow for the lower part

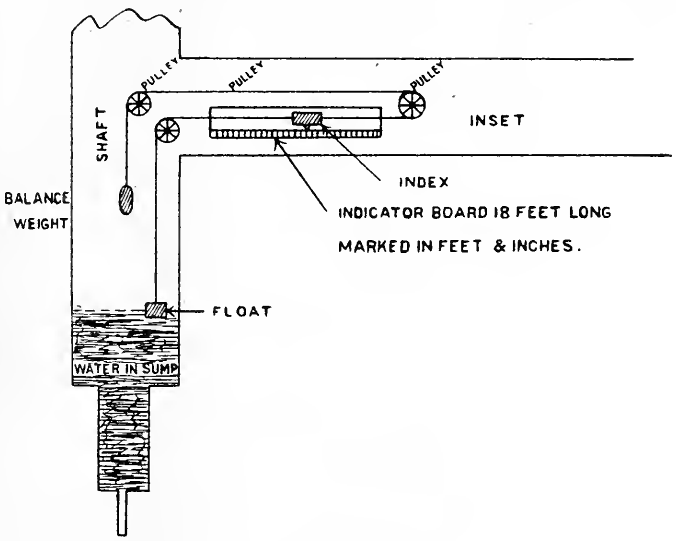

FIG. 2.

will probably be greater than for the upper, the estimate of 20,000 gallons an hour will not be far out. The writer suggested that the apparatus sketched above (fig. 2) should be fixed to enable accurate observations to be made.

The apparatus would consist of a float and a counterpoise in the sump attached to an indicator by a thin flexible chain. The float and its counterpoise could be arranged to work inside fixed pipes so as to avoid catching the side of the shaft. The float-pipe should have a very free inlet at the bottom for the water. The indicator should be marked in feet and inches, and very accurate records of the rate of flow of the water could be made by timing the index whilst the sump was filling after being emptied.

Many of the Bikanir wells have struck the water-bearing sandstone much above the Palana level, though about the same distance from the surface. The sump at Palana fills very rapidly, but the water, at the most, rises only a few feet above the sandstone; it is obvious, therefore, that the water is not pounded, but has a very free outlet. From information, it is gathered that none of the wells are sunk more than six feet into the sandstone. The water-supply is unfailing, and does not appear to vary much with the seasons. The above facts seem to justify the conclusion that there is an enormous flow of water under Bikanir (much greater than hitherto suspected), and that we must look to the snow-fed rivers from the Himalayas for the source. Judging from the maps, some of these rivers disappear to the south of Bhatinda, but the writer has not had an opportunity of examining the district. Possibly information on these points may be found in the "Records of the Geological Survey of India," but these are not available to the writer at present. The Palana Coalfield was described by Mr. T. D. La Touche.[1]

Specimens of the strata at Palana were kindly given to the writer by Mr. W. H. Phillips. The sandstone was taken from the sump during his visit, and is probably the first specimen preserved. It will be noticed that it is very soft and loose-grained.

The writer was informed that gravel and crystals have been found in the water-bearing strata at the bottom of

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1 "Records of the Geological Survey of India," Vol. 30, Part 3.

the wells, and that pieces of wood dropped down one well in Bikanir town were found in another a quarter of a mile away. It seems to the writer that, both from a scientific and practical point of view, the phenomenon of Bikanir water deserves a thorough investigation. The information might be collected under the following heads :—

(1) The positions, height above the sea-level, and the exact depth to the water-bearing strata of all wells.

(2) The collection of old records and traditional information.

(3) Recording the quantity of water obtainable from the wells.

(4) What is the source of the water ?

(5) Is there a danger of the supply being cut off by irrigation works or otherwise ?

(6) Where is the outfall ?

(7) What quantity of water (approximately) is flowing under Bikanir ?

(8) Are there any places where folds of the strata would cause the water to come to the surface if the impervious clays were pierced ?

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Part 3] 1910. [February.

Manganese-Ore Deposits of the Sandur State.

BY

A. Ghose, F.C.S., F.G.S., M. Inst. M.E.

Read at the General Meeting held at Asansol, Aug. 23rd, 1909.

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MAPS.

I.—INTRODUCTION.

1. The Dharwars—The Principal Metalliferous Formation in India.

(1) The Dharwars.

The deposits of manganese-ore under notice occur in a region of rock formation the distinctive character and sedimentary origin of which were first discovered by Mr. R. Bruce Foote, Superintendent of the Geological Survey of India, in the neighbourhood of the town of Dharwar in the south of the Bombay Presidency, where this formation shows conspicuous development; hence the name 'Dharwar System.' This important series of rocks, consisting of argillaceous, chloritic and hornblendic schists and banded hematite, magnetite and limonite quartzites with numerous contemporaneous trapflows, resting on the fundamental complex, is supposed to comprise the oldest sedimentary formation, which was subjected to enormous pressure in the Pre-Cambrian epoch, being upturned and contorted in great north-north-west and south-south-east folds which subsequently underwent extensive denudation. The remnants of this schistose series, which originally covered an enormous area of the land surface of the

Peninsula, are now traceable in a few striking bands in Southern India. The hill ranges of the Sandur State in the Madras Presidency form one of the most interesting and well-developed bands of the Dharwar system.

(2) Metalliferous minerals: iron, manganese, copper and gold.

This rock series is notable as the repository of valuable metalliferous minerals, all the principal and productive auriferous tracts of India being located within its limits. The auriferous features of certain areas were so prominent that the ancients, in spite of their limited knowledge and scanty means, have left innumerable relics and ample evidence, in the shape of numerous shafts sunk in quartz reefs scattered over large areas, of an once flourishing gold-mining industry which, after a lapse of centuries, has been revived in the Kolar and the Dharwar gold fields. Besides gold, copper ore has been worked extensively in the Dharwar rocks in more than one locality. The most striking feature of the Dharwar band in the Sandur area is the immense development of the deposits of iron and manganese ores on a scale scarcely surpassed by similar occurrences elsewhere.

2. Early Discoveries and Previous Notices.

(3) Newbold's discovery.

The existence of small quantities of manganese-ore "in the primary schists" of the Sandur State was first discovered by that keen observer and pioneer of Indian Geology—Captain Newbold—so far back as 1838.[1] Surgeon-General

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[1] Captain Newbold, F.R.S.,—" A cursory Notice of the Gold Tract in the Kupputgode range—Manganese Mines near Wodoorti, etc.," in the " Madras Journal of Literature and Science," vol. xi, 1840, p. 46.

Note:—Since the completion of this paper, the author has come across an earlier notice of the occurrence of manganese-ore in the Sandur Hills in " Some

Balfour notices the occurrence of manganese ore, associated with iron ores, in the Bellary District.[1] These authorities do not specify the localities where the ore was found to occur. In his "Economic Geology of India," Dr. Ball mentions the existence of manganese ore in the Bellary District on the authority of Dr. Balfour.[2]

(4) Foote's discoveries.

While describing the "Dharwar system—the chief auriferous Rock-series in South India" in 1889, Mr. Bruce Foote records the occurrence, in considerable quantities, of manganiferous concretionary nodules in an exposure of schists and argillites on the western slope of the hill which is crossed by the road from the plateau of Ramandrug to the village of Narain Devar Keri in the plain.[3] In his "Notes on the Economic Geology of Sandur State"[4] published in 1889, Mr. Bruce Foote describes the occurrence of manganiferous nodules "at two localities, namely, at Ramandrug and near Kanevihalli." In 1890 Dr. King reviews this discovery in the "Annual Report of the Geological Survey of India."[5] In the Records of the Geological Survey of India (1890), Vol. XXIII, part 3, the occurrence of the ores of manganese in the Sandur Hills is noted by Mr. Bruce Foote. In the "Memoir on the Geology of the Bellary Bistrict," the same observer gives

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Account, Historical, Geographical and Statistical, of the Ceded Districts" by Lieutenant Newbold in the above Journal (vol. x., 1839, p. 125).

1 Surgeon-General E. Balfour,—Article on Iron in the "Cyclopædia of India," third edition, 1885.

2 V. Ball, M.A., F.G.S.,—"A Manual of the Geology of India," part iii, "Economic Geology" (1881), p. 327.

3 "Records of the Geological Survey of India," vol. xxii, p. 26 (1889).

4 R. Bruce Foote, F.G.S.,—"Notes on the Economic Geology of Sandur State" published by the Political Department, Government of Madras (1889).

5 W. King, B.A., D.Sc.,—"Records of the Geological Survey of India," vol. xxiii, p. 1.

a fuller description of these and similar manganese ore-occurrences in the Sandur State.[1] In all, four localities were discovered by Mr. Foote, namely, (1) one on the western slope of the Ramandrug Hill, (2) another on the western flank of a small spur two miles south of Kanevihalli, and (3 and 4) two other localities some 7 and 8 miles respectively south-east of the Kanevihalli spur and on a narrow terrace a little below the edge of Kumaraswami, Plateau. In all these places manganese nodules were found imbedded in argillaceous schists, and the most promising locality, according to Mr. Foote, was the one two miles south of Kanevihalli where the nodules were fouud to range in size "from that of a small nut up to a child's head" and occurred " in large numbers, and could easily be quarried along the bare side of the hill and shot down to the foot of the spur whence to be carted on a tram and carried to the nearest railway at a very small cost."

In 1904, Mr. W. Francis in the Gazetteer of the Bellary District gives a short account of the above manganese-ore occurrences.[2] In 1905, Mr. (now Sir) T. H. Holland, the Director of the Geological Survey of India, mentions the reported occurrence of the ore in the Sandur Hills of Bellary.[3] In 1906, Mr. L. L. Fermor,[4] Deputy Superintendent of the Geological Survey of India, describes in detail a specimen of manganite found at

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1 R. Bruce Foot, F.G.S.—" Geology of Bellary District "; " Memoirs of the Geological Survey of India " (1896), pp. 100—125, 194—196.

2 W. Francis, I.C.S., Gazetteer of the Bellary District (1904), p. 17.

3 T. H. Holland, F.R.S.—" Review of the Mineral Production of India during the year 1898 to 1903 " in the " Records of the Geological Survey of India," vol. xxxii, part i (1905), p. 57.

4 L. L. Fermor, A.R.S.M., F.G.S.—" On Manganite from the Sandur Hills " in the " Records of the Geological Survey of India," vol. xxxiii, part 3 (1906), pp. 229—232.

Ramandrug, and notices in brief the occurrence of "an outcrop of huge boulders of psilomelane extending about 450 feet along the strike." In the same year, the same authority, in his contribution on "Manganese in India" in the Transactions of the Mining and Geological Institute of India, while classifying the Indian manganese-ore deposits, considers the Sandur Hills manganese-ore formation as "psilomelane and pyrolusite superficially formed on the outcrops of rocks of Dharwar age."[1] He mentions the discovery of manganese ores in the Sandur area by Newbold and Mr. R. B. Foote, and the working of the Ramandrug deposits. He also quotes analytical results showing the composition of the ores.[2] In 1906, Mr. T. D. LaTouche, Officiating Director of the Geological Survey of India, notices the grant of a prospecting license for manganese-ore in the Bellary District.[3] In 1907, the present writer mentions the carrying on of mining operations on a large scale in the Sandur State, and points out the possibility of the Sandur ore-deposits taking an important part in the world's production of manganese-ore.[4] In August, 1908, Dr. Malcolm Maclaren, while describing the auriferous deposits of India, mentions the existence of "extensive deposits of lateritic manganese" in the Sandur State."[5] More recently, Sir Thomas Holland, in his "General Report

(5) Recent notices, and Fermor on the Sandur deposits and manganite.

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1 L. Leigh Fermor—"Manganese in India" in the "Transactions of the Mining and Geological Institute of India," vol. i, part 2 (1906), p. 86.

2 L. Leigh Fermor—"Manganese in India," pp. 99—100 and 101.

3 T. D. La Touche, B.A., F.G.S.—"The Mineral Production of India during 1905," in the "Records of the Geological Survey of India," vol. xxxiv, part 2 (1906).

4 A. Ghose—"Prospects of Indian Manganese Industry" in the "Journal of the Society of Arts," No. 2854, vol. lv (1907), p. 912.

5 Dr. Malcolm Maclaren—"The Auriferous Deposits of India" in the "Mining Journal" (1908), p. 199.

of the Geological Survey of India for the year 1907,"[1] referring to the manganese-ore deposits of the Sandur State, says:—"Mr. Fermor concludes that the manganese and associated iron-ores are formed as weather-products from hematitic schists and slates similar to those on which the ore-deposits now lie. In spite, however, of the fact that the ore-bodies must be described as superficial, there is no doubt that millions of tons are available on the Ramandrug plateau: it has yet to be proved that the ores of the Central Provinces will be more lasting than some of these so-called superficial deposits." This is the only statement, so far published, on the Sandur deposits, which is based on the recent discoveries, which form the subject of this paper.

Besides the above and some stray notices in the Administration Report of the Sandur State, and in some newspapers in India, so far as the writer is aware, nothing has been published on the subject of the Sandur manganese ore-deposits.[2] It may be mentioned here that Mr. L. L. Fermor, who has made a special study of the manganese-ore deposits in India, and who is an authority on the subject, was deputed towards the end of 1907 by the Director of the Geological Survey of India to examine the Sandur area, and the above remarks of Sir Thomas Holland are based on his observations. It is understood that Mr.

(6) Fermor's researches.

1 Sir T. H. Holland, K.C.I.E., D.Sc., F.R.S.—"Records of the Geological Survey of India," vol. xxxvii, part i, p. 32.

2 It is only natural that in the absence of any knowledge or previously published information on the subject of the existence of enormous deposits in the Sandur State, in M. Leon Demaret's memoir "Les Principaux Gisements des Minerais de Manganese du Monde," which appeared in 1905 in the "Annales des Mines de Belgique," there is no mention of the Sandur deposits.

NOTE.—Since the completion of the present paper, a short contribution on the Sandur manganese-ore deposits by Mr. R. O. Ahlers, entitled a "Manganese Deposit in Southern India," has been published by the Institution of Mining and Metallurgy.

Fermor's researches will be embodied in his memoir on the manganese-ore deposits of India, the publication of which is awaited with interest, as there is reason to suppose that it will be a valuable contribution to science and to the literature on the manganese-ore industry.[1]

II.—GEOGRAPHY OF THE SANDUR AREA.

1. SITUATION AND MEANS OF COMMUNICATION.

(7) Situation and boundaries.

The State of Sandur is situated in the Bellary District of the Madras Presidency. On the north, east and west it is bounded by the Hospet Taluk, and on the south by the Kudligi Taluk, while a portion of the south-eastern extremity abuts on the Mysore State. The area covered by the Sandur State is entirely comprised within the meridians 76° 21′ and 76° 44′ east of Greenwich. On the north and south, it is limited by the parallels 14° 58′ and 15° 14′.

(8) Area.

The Sandur State is one of those principalities which owe their existence to the singular clemency of the British Government in permitting certain Indian Chiefs, in recognition of their allegiance, to retain and rule their hereditary possessions. The present Raja, H. H. Srimant Venkata Rao Rao Sahib Hindu Rao Ghorpade, is a descendant of a noble Mahratta family. The State comprises an area of 158·43 square miles, of which only 19 square miles are cultivable, the rest being covered with forest and waste land.

Good metalled roads connect the town of Sandur,[2]

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[1] The author now records with pleasure the publication of Dr. Fermor's memoir—"The Manganese-Ore Deposits of India—which is a monument of research and industry. 12 1-'10.

[2] Sandur, or more correctly Soondoor, is derived from Soondara Ooroo or 'beautiful village,' not that the village was beautiful in former times, but because of its picturesque surroundings composed of ridges crowned by vividly coloured banded jasper cliffs, and the deep contrast supplied by forest scenery.

the capital of the State, with the Southern Mahratta Railway System. From Tornagallu, a station on this Railway, Sandur is at a distance of 12 miles in a south-westerly direction. The hill-station of Ramandrug which is 8 miles from Sandur and is within the State limits, is connected with the Railway Stations at Hospet, Ramanmalai and Mariamanhalli by ghat roads. Bellary, the headquarters of the district and the seat of the Political Agent for Sandur State, is 30 miles from Sandur, and is connected by a good road which crosses the State from east to west through two gorges and leads to Kudligi, an important town 12 miles from the western boundary of the State. There is direct communication between Hospet—an important Railway Station—and Sandur. But a portion of this road is difficult even for carts owing to defective construction. There is direct communication beween Sandur and Marmagoa Harbour on the West Coast through Tornagallu, Hospet and Mariamanhalli Stations. The distances are as follows :—

(9) Roads and railway communication.

Tornagallu to Marmagoa	..	..	$234\frac{3}{4}$ miles.
Hospet ,,	..	..	$214\frac{3}{4}$ miles.
Mariamanhalli ,,	..	..	$228\frac{1}{2}$ miles.

The recently constructed railway siding, at the foot of Ramandrug hill, is 5 miles from the top of the plateau. The distance between Hospet and Madras is $346\frac{1}{2}$ miles.

2. TOPOGRAPHICAL SKETCH.

The Sandur band essentially consists of parallel ranges of hills, which are continuous throughout their longitudinal extension, save where they have been cut by the transversal passage of the Narihalla. In broad outline, the parallel ranges of hills appear to occupy a canoe-shaped area due to the convergence of their apices at the north-north-west and south-south-eastern extremities. The band which is distended at the middle, extends for a length of nearly thirty-six miles—from its extreme northerly point four miles north-west of Hospet to its southern extremity where it terminates four miles south-east of Gola Lingamanhalli village. Besides the northerly and southerly extremities, the main portion of the hill ranges are comprised within the limits of the Sandur State. The ridges are long and continuous, having few rugged elevations. At places they rise to a height of over 1,000 feet above the plain. Kalhalli Gudda is the only portion of the ridge which attains the highest elevation in the British territory a few miles from Hospet. The hills reach their maximum elevation in the south about a mile west of Kammat Haruvu, where the culminating point at Hiray Gutti, the highest peak on Malliama Haruvu, attains the height of 3,400 feet above the sea level. The highest point on the plateau of Ramandrug (3,256 feet above the sea level) is situated near the great Trigonometrical station, which is marked by a rude stone circle not far from the 38th mile-stone on the Bellary Road.

(10) Limits of the Sandur Ranges.

The hill ranges strike in a north-north-west direction, and the longer dimension of the median valley follows the same direction. This north-north-west trend of the hill ranges and of the valley has been determined by the similar strike of the rock formation, which has been upheaved subsequent to its deposition on the floor of the Archæan Ocean and folded locally into a great synclinorium. The western and the eastern limbs of the syncline have probably been rent asunder by a great fault which gives rise to five

(11) Five main divisions of the ranges.

natural divisions. The (1) Ramandrug Range and the so-called (2) North Eastern or Timappa Range are situated to the north of the Narihalla and its two fine gorges, called Obla Gandi[1] and Bhima Gandi respectively. The continuations of the above divisions to the south of the river are the (3) Kanevihalli Range including the Kumaraswami section and the Kammat Haruvu extension on the west, south and south-east, and the (4) Done Malai on the east, and (5) the Devadari ridge, which now occupies an isolated position, bifurcates the Sandur valley towards its southerly extension.

(12) Plateaus and talus slopes.

The ridges are crowned by a series of plateaus of considerable longitudinal extension. The westerly fringe of the plateaus surmounting the western ridge frequently terminates in highly inclined strata of iron or manganese ore, which are succeeded by bold precipices of a schistose rock which skirts almost the entire length of the range from its north-westward extension beyond Ramandrug Hill to the extreme south-easterly point of the Sandur band where it ends

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1 Mr. Foote in his "Memoir on the Geology of the Bellary District" (p. 34) speaks of "the extraordinary dearth of legends connected with the geological features" of the district. To show that his remarks do not apply to the Sandur area, which has been made the scene of actions in the Mahabharata, Ramayana and the Puranas, it may be permissible to cite some stories in this paper. The gorge 'Bhima Gandi' or Bhima's Gate and 'Bhimatirtha' or the pool of Bhima, derive their names from one of the five Pandava brothers the heroes of the Mahabharata—the great Indian epic. The story goes that Bhima made the depression which now contains the pool of water, "with a blow of his club and the prints of his feet are shown on the rock. The pool is held sacred. Brahmans bathe in it on certain holy days and the ashes of their dead are thrown into it, the belief being that it is connected by subterranean ways with the Tungabhadra" ("Gazetteer of the Bellary District" by W. Francis, I.C.S.). The other gorge derives its name "Obla Gandi"—a corruption of "Ahobala Gandi" or 'Ahobala's gate' from the fact that it gives access and is situated close to the temple of Ahobala Narasimha, the man-lion incarnation of Vishnu.

abruptly in the Golla Lingamanhalli valley. The cliff forming schistose rock again appears on the eastern flank of the eastern side of the syncline. Cliffs of banded jasper of great vertical and horizontal extension dominate the ridges forming the sides of the Sandur trough. The slopes of the ridges, which are covered by immense talus accumulations and which commence from the foot of the precipices formed by the banded jasper and the schistose rock, are comparatively steep on both the eastern and the western sides of the ridges, merging gradually nto the plains lying at their base or into low spurs. The highly inclined and much jointed schistose strata have yielded under the meteoric influences forming the talus slopes. Where the rocks have resisted weather action the accumulation of talus is not deep and, consequently, the slopes are steeply inclined. The slopes are not continuous over long distances as they are cut by deep ravines which flank them on either side.

(13) Ravines.

The mechanical action of streams originally flowing from the summit of the ridges, has excavated numerous deep ravines which constitute prominent features in the Sandur landscape. The ravines flank all sides of the ridges encircling them throughout their extension and forming a chain of succession with a marked regularity of interval. This gives a symmetrical appearance to their disposition which is apparent on the map. The soft schistose rocks and, in many cases, the highly jointed structure of harder rocks determined the position and courses of the valleys and ravines. The principal type of ravines has been formed by erosive action operating mainly across the folds. But there are several cases, specially in the southern part of the Sandur Ranges, which show that the denuding agencies have sculptured ravines which follow the strike of rocks; but, these frequently ramifying, pass into the first type.

(14) Hydrology.

The name Narihalla or "women's river" appears to have been ironically applied to the small river which rises in the British territory, a few miles west of the State, and after traversing the synclinal basin at its widest part through the two gorges, falls into the great Darojee tank situated at the northern extremity of the Copper Mountain Range. This is the only river which drains the Sandur area. The numerous small hill streams fall into four major streams which ultimately empty their contents into this main channel. The aridity of the Bellary District is such that no water is found in the streams and in the river except during the prevalence of monsoon conditions.

(15) Survey map.

The latest map of the Sandur State on a scale of 1 inch to a mile, first published by the Madras Survey in 1905 and reprinted in 1907, delineates the configuration of the Sandur area with remarkable accuracy. Only on the west of the great plateau known as Kammat Haruvu details are wanting to show the disposition of the neighbouring isolated plateaus, named Hanumanthana Haruvu and Mannal Haruvu, which are separated from Kammat Haruvu by a system of great ravines which find no place on this otherwise good specimen of topographic work.

3. LOCAL GEOGRAPHICAL TERMINOLOGY AND ORIGIN OF PLACE NAMES.

(16) Origin of place names.

Although the Sandur State has been under the Maharastra influence since 1728, Canarese is the prevailing vernacular of the inhabitants of the State. There can be little doubt that the Boyas[1], who migrated to the Sandur area before the Maharatta and the Mahomedan invasions, belonged to the Canarese-speaking sect, as is testified by the Canarese geographical terms still current in the state. The Boyas originally formed a warlike caste and their sporting instincts and love of manly sports characterise them as a hunting tribe. The valley of Sandur, surrounded by forest-clad hill ranges forming natural defences, induced them to settle in the old turbulent times: further, they had ample field for hunting; for in those days, the Sandur Forests, there are reasons to suppose, teemed with wild animals. Predatory warfare, hunting expeditions, and pastoral occupations, probably led to the exploration of the Sandur area; and the configurations of the land were differentiated in such a way that it is remarkable

[1] The following story on the origin of the Boyas is quoted here as it has a touch of seismic interest. In the days of old, the chief of a wandering band of robbers who lived by hunting and plundering became a devout worshipper of Shiva—the Creator. This chief used to repair daily at noon to a temple of the god in the forest and worship the deity with various offerings. A Brahmin also used to worship in the same temple in the morning and was grieved to find that the god was not pleased with his devotions. Parvati, wife of Shiva, was surprised that the god was always pleased to accept the offerings of the Boya in spite of his low origin. On enquiry, Shiva promised to prove to her that the Boya was sincere and the Brahmin was not. When the Brahmin came next morning with flowers and offerings, a terrible roar issued from the earth, which began to quake in such a way that the Brahmin, fearing that the temple would topple over, ran away as fast as he could to save his life. When, at noon, the Boya arrived at the temple a most terrible roar, greater than the first, issued from the earth, which shook in such a way that the idol swayed from side to side, and it looked as if the temple was going to collapse every moment. Yet the Boya, not thinking of his own safety, held down the idol steadfastly till the terrible subterranean rumbling ceased, upon which Shiva and Parvati were so pleased that they revealed themselves before the Boya and wished to know from him his desires. The Boya replied that he wished to be blessed with "five children, the fruits of the chase, and the products of the jungles for their support, with water from the streams and pools, and a firebrand to light his way and prepare his food." Needless to say his modest request was immediately granted.

that every hill, ravine, and all topographical features within the Sandur limits were endowed with distinctive names, which have been handed down to successive generations. Most of these names probably originated in an attempt to simplify the identification of localities for hunting purposes and some are undoubtedly associated with historical events, mythological personages or prominent landmarks; again, many have been named after animals or plants. The local geographical terminology is interesting, as it embraces and distinguishes nearly all the topographical features of the area and speaks not a little for the discriminating power of the Boyas. The following is a comprehensive list of the more important terms with their English equivalents :—

1. Malai—Hill Range.
2. Gudda—Mountain or high hill.
3. Betta—Hill.
4. Maridi—Low Hill.
5. Gutti—Hillock.
6. Mutty—Hill of small elevation.
7. Gandi—Gorge.
8. Kanemi—Pass, also saddle.
9. Tippa—Rock Terrace.
10. Wadai—Precipice.
11. Kativi—Cliff or spur with steep slopes.
12. Mulay—Promontory.
13. Yenu—Ridge.
14. Tattu—Ledge.
15. Dinnay—Elevated ground equivalent to peak.
16. Haruvu—Plateau.
17. Thaggu—Valley or depression.
18. Gavee—Cave.
19. Padi—A flat projecting rock.
20. Gundi—Basin.
21. Kolla—Ravine.
22. Bylu—Plain.
23. Holee—River.
24. Halla—Stream, Rivulet.
25. Saruvu—Hill Stream.
26. Honda—Natural reservoir.
27. Gadday—Bank.
28. Bugge—Spring.
29. Kera—Lake.

(17) Derivation of local names:—The Hill Ranges.

The derivation of the local place names is of considerable interest. As has been stated before, the hill ranges of the Sandur State may be divided into five sections, each of which has been given a separate name by the original inhabitants to facilitate identification. Thus, the western portion of the synclinal arm north of the Nari-Halla owes its name to Kumara Rama—a poligar[1] (who is supposed to have built the fortress on the plateau known as Ramandrug) and the whole range is called Ramana Malai. The eastern section, the continuation of which has been named as the North-Eastern Range on the 1-in. scale map of the Madras Survey, is named Timappa Gudda after the god Timappa whose ancient temple crowns the ridge. It is only by this latter name that this range is known to the local people. The portion of this hill range, south of the Bhima Gandi, is known as Doni Malai, as there is a large depression (Doni, *i.e.*, waterhole) on the top of the plateau, where rain water collects in considerable quantities. The southern portion of the hill ranges forming the Sandur syncline has been named Kammat Haruvu after the plateau of that name. The western arm of the syncline, south of the Narihalla, is commonly known as Kanevihalli Gudda after the important village of Kanevihalli, situated about one mile from the entrance to the western gorge. The Kumaraswami valley is named after the presiding deity of the same name. The central range, occupying the southern portion of the Sandur valley, has been wrongly named as Devadaru Gudda and it is known by this name to the people. The correct name is Devadari Gudda and, according to Hindu Mythology, the hill derives its name from an incident in the career of Kumaraswami, the commander of the heavenly host.

The flat-topped hill ranges of the Sandur State

1 Tamil designation for a chief, derived from *pallay*—a collection of troops.

comprise several plateaus, and each of these has been given a separate name to facilitate identification. Thus the plateau with cultivation has been known as Kammat Haruvu ('Kammat'—'cultivation,' and 'Haruvu'—'plateau'), as this was the only plateau on which large plots of lands used to be cultivated and are still cultivated, the other plateaus being hardly under cultivation. Aldmara Haru is the name given to the large plateau on the Kanevihalli Range, as a banian tree (Ald Mara) once formed a conspicuous feature on that plateau and its offshoots have now taken its place. The plateau, south of Ramandrug, is also known as Aldmara Haru for the same reason. Yello Suttina Kotay Haruvu, the plateau which is situated at the apex of the Kumaraswami Valley, derives its name from Yello Suttina Kote, *i.e.*, the fort with seven walls: the existence of this fort has almost completely been obliterated. Malliama Haru, a narrow plateau which forms an arm of Kammat Haruvu, is named after the goddess Malliamma, whose temple is situated on this plateau. Hanumanthana Haruvu derives its name from the monkey god, who is extensively worshipped in Southern India.

(18) The plateaus.

The Sandur ravines have received more attention from the original inhabitants than any other geographical features; for their comparatively thickly-wooded character led to their being the favourite haunts of wild animals, in the pursuit of which the ravines were thoroughly explored and named by the primitive geographers who belonged to the hunting tribe and subsisted on the fruits of the chase. This is the reason why not a few of the ravines are named after animals such as Kadathi (stag) Kolla. Many, again,

(19) The ravines.

are named after plants, for example, Alada Marada (banyan tree) Kolla, Mavinmarad (mango tree) Kolla, etc. Some derive their names from mythological personages such as Durgamma Kolla, Ram Kolla, Shankar Kolla and others. Ravines in which springs exist are generally named as Neer (water) Kolla. The ravine to the west of Durgamma Kolla is called Joganna Aditha (play) Kolla, because it appears that in ancient times it was used as a sort of playground by a chief named Joganna. Various other instances of curious origin of local place names may be cited.

III.—GEOLOGY OF THE SANDUR BAND.

I.—REVIEW OF THE PREVIOUS CONTRIBUTIONS ON THE GEOLOGY OF THE SANDUR AREA.

I.—*Newbold's Description of the Sandur Area.*

(20) Newbold's and Foote's researches.

Newbold's "Description of the Valley of Sandur,"[1] although published so far back as 1833, summarises the salient features of the geology of the area in a way which can hardly be improved upon even in the light of modern knowledge. The geology of the Bellary District was the subject of investigation by the Geological Survey of India during the years between 1884 and 1890. The work was carried out by Mr. Bruce Foote, then Superintendent of the Geological Survey of India. The detailed results of Mr. Foote's investigation were published in 1895. Although Mr. Foote had previously published some accounts of the Sandur geology, these were comparatively brief. In this "Memoir on the Geology of

[1] Journal of the Literary Society of Madras, vol. viii, pp. 128—152 (July, 1838).

Bellary District,"[1] the Sandur area was fully described with a wealth of detail and picturesqueness which is characteristic of the discoverer of the Dharwar system.

(21) Summary of Newbold's description.

Newbold describes the "prevailing rock met with as a chloritic slate, resembling the greenish graywacke slate of Britain, often highly impregnated with oxide of iron and crested in many places with natural ridges of a ferruginous quartz rock, embracing a variety of colours from steel-grey to a deep liver-brown and of different degrees of compactness." He gives a detailed description of the fissure, which he styles as "the most striking geological feature" of the area. The discovery of several waterworn pebbles, near Bhimagandi or the eastern pass about 50 feet above the bed of Narihalla, on a ledge of the southern rock, is recorded. The finding of one or two pebbles of chloritic slate leads him to conclude that the chloritic schist "once formed most probably the part of the bed of an ancient and higher channel." He also notices the occurrence on the bank of the Narihalla, of a peculiar conglomerate composed of rounded pebbles cemented together by carbonate of lime and oxide of iron. The mineral character of the gorge bed is described as "a jaspery clay highly impregnated with iron, occurring in alternate lamina with cherty quartz, imbedding red striped jasper in rhomboidal and curved fragments and contorted veins, nests of decaying felspar and vescicular iron ore." The rocks of Oblagandi—the western gorge—were found to possess a similar character. Newbold notes the occurrence of chloritic slate in several small hills (running parallel to the main ranges) in the valley of Sandur.

[1] R. Bruce Foote, "Geology of Bellary District," pp. 91—128.

He also notices large calcareous deposits on the banks of the rivulets, some of which were associated with nodular and concretionary iron-ore. The southern extremity of the Sandur Range is well described by Newbold. The schist at the base of the range, which is crossed by the road to the Kumaraswami Temple, is succeeded by masses of lateritic rock somewhat dissimilar to the laterite of Malabar, and the characteristics of the former are compared with those of the latter. Then follows a short description of the laterite capping this portion of the ridge near the above-mentioned temple. The occurrence, in the same locality, of "large beds of kaolin" and its association with soft reddish, or purplish shale derived from decomposing felspar and quartz, is recorded. "At the southern base of the hill gneiss is seen alternating with mica, felspar, hornblende, quartz and talcose schists, in contorted strata; with the general direction of S. 25°-E. and dipping N. 45° W. at an angle 46. Granite clustered masses rise from the gneiss and its associated schists, at a little distance in the plain accompanied by dykes of greenstone."

2.—Foote's Geological Survey.

(22) Foote on the geology of the Sandur hills.

Foote divides the Sandur hills into four divisions to facilitate his description of the geology of the area: two of these, namely, Ramandrug and the Ramgol divisions, lying north-west of the Narihalla, and the remaining ones, namely, the Donimalai and the Kumaraswami divisions, lying south-east of the river. Foote gives lengthy descriptions of each division, the principal points of which are touched on in this summary, which deals only with the western arm of the syncline, containing most of the manganese-ore deposits. Foote speaks of the difficulty in correlating exactly all the beds of both sides of the syncline and of the uncertainty as to the continuity of the several hematitic beds. Still he considers it "safe to regard the Hoshalli trapflow in the south-eastern valley between the Donimalai and Devadari spur of the Kumaraswami division as the central and uppermost bed of the synclinal." The section along the Narihalla throughout its length within the limits of the Sandur State shows the sequence of rock succession, the prevailing rocks met with being schists of different composition, hematite quartzites and contemporaneous trapflows. Foote has no doubt as to the inversion of the eastern side of the synclinal affecting the "beds only in the central part of the ellipsoid," the remaining portions of the beds being in their normal position.

(23) Ramandrug or north-western division.

The Ramandrug division is described as a very acute isosceles triangle extending from the Narihalla western gorge to the banks of the Tungabhadra for a distance of 19 miles. The succession of rocks met with along the Naraindevarkera ghat road, across the ridge and down its eastern slope, is listed and correlated with the Narihalla section, and the relationshsip between the five Ramandrug "Hematite beds" is established with those of the Oblagandi gorge section of the Devadari beds. The two exposures of the trapflows in the Ramandrug ridge are also correlated with those of the Narihalla section. The ridge is described from south-east to north-west. The hematite beds forming the crest of the hill are continuous for about five miles and then gradually becoming less ferruginous lose their distinctiveness among the hard green chloritic schists which predominate. The great cliff of "hematite beds" forming the crest of the Ramandrug ridge south-south-west of Maderhully shows a thickness which must amount to several hundred feet. Half a mile further north the beds seen in the section, which are the Ramandrug (Trigonometrical Station) and "red cliff" beds of the Ramandrug sections, sink and trend away down into the valley, and two of the more westerly beds take their place, forming the crest of the ridge. These appear to continue to the south of the ridge. The northern end of Ramandrug ridge is obscured by the great hematitic talus accumulation along the base of the Sandur Hills which conceals the junction with the gneiss along the western base for fully 13 miles. Attention is drawn to the rich red soft argillaceous hematite boulders in the talus formation as a suitable material for the manufacture of red paint. The occurrence of manganiferous nodules in the argillite beds exposed in the section on the western slope of Ramandrug is also noted. The hematitic debris covering the summit of the Ramandrug range is divided into two classes: the first occurring "as an ordinary pseudo-laterite, either massive or encrusting," and the second "as a breccia of angular fragments of hematite rocks, often very rich in iron." The description of the Ramandrug division concludes with an account of two more "hematite" beds (named by Foote after Bavihalli and Hunasahutti, villages in the neighbourhood) and of a section across the Bavihalli ridge.

(24) The Kumaraswami division.

The Kumaraswami division of Foote embraces the south-western half of the western side of the Sandur synclinal, including the Devadari ridge occupying the centre of the southern half of the Sandur valley. It is twelve miles long from the north-west to south-east and nearly seven miles broad at the northern end where it attains the maximum width. The hematite quartzites again in this area show conspicuous development. This area exhibits the least deformation, and the "marked absence of jaspideous character in the poorer hematite quartzites" is cited as "evidence that the rocks here have undergone less deformation than the other parts of the synclinal." The great hematite quartzite bands of the Devadari group of hematites are traced to the western flank of the narrow Appianhalli synclinal. These ultimately die out in the vicinity of the granite gneisses of the Golla Lingamanhalli valley just beyond the stream at the south-eastern end of the Sandur area. Here there are a few irregular patches of the Dharwar rocks. These are "preserved merely because protected by surrounding irregular hummocky masses, which evidently formed part of the rugged old surface on which the Dharwar system was deposited; they had in fact been deposited in depressions in the old granitic surface."

(25) Kammat Haruvu section.

The great hematite quartzites of the Devadari spur are mainly lost sight of after joining the plateau known as Kammat Haruvu. Only one of them outcrops conspicuously, and that at a point half a mile south of Kammat Haruvu where it forms the broad crest of a ridge some 150 feet in height consisting entirely of pure steel grey crystalline hematite. This was the richest deposit of iron-ore found by Foote in the Sandur Hills or in any Dharwar tract seen by him. The remaining portion of the plateau is very level and its surface "entirely hidden by local pseudo-laterite and thick red soil." The uppermost band of the Devadari hematites forms the eastern edge of the plateau for "several miles." But the lowest band cannot be traced.

"The Devadari hematites are underlain by a great contemporaneous trapflow, which occupies a wide space in the valley around Sandur town and fills a great part of the Nandihalli valley (the south-westerly fork of the main valley), but which narrows greatly to the south-east in part, apparently, from actual thinning out, but in part also from the strata of all kinds being there tilted up at much higher angles than further north." Underlying this great trap formation, the "Sandur trap" of the Narihalla section, and forming the south-western side of the Nandihalli valley, which, along the northern edge of this part of the Kumaraswami plateau, rises very steeply, and is in places distinctly scarped, comes the great series of hematite quartzites "seen in their north-western extensions in the Ramandrug Division." Towards their south-easterly extension into the southern half of the plateau, they are obscured by a pseudo-lateritic formation and their further existence becomes problematical. The description of the Kumaraswami division is followed by an account of the Adargani iron-ore mine of the Tonashagiri hematite series and associated "lenticular concretions" of manganese ore, and of the existence of veins of crystalline limestone in argillite near the Adargani footpath. A section to the north of Saniasihalli village is described, and the occurrence of hornblendic, micaceous, and chloritic schists on "hummocky granite gneiss", near Somalapur village (where potstone beds of the Dharwar age exist), west of the Obla-gandi gorge, is noticed; and with this Foote's account of the geology of the Sandur area is brought to a conclusion.

(26) The Sandur trap-flows.

II.—Author's Observations.

1.—*General Geological Features.*

The Sandur band is structurally a great trough of sediments of the Dharwarian age bordered mainly on all sides by granites and gneisses of doubtful Archæan origin cut by post-Archæan acid eruptives and basic dykes. To the east, there is a narrow expanse of the Dharwar schists, which is co-extensive with the Sandur formation and serves as the connecting link between the Sandur and the so-called Copper Mountain band. The Sandur trough is a syncline of the simplest type. The limbs of the syncline run in a N.-N.-W. direction converging at their ends. The strata are repeated on either side of the axis and, interpreted structurally, show the synclinal character of the band. With some exceptions where the strata have been highly disturbed and inverted, the opposed dips on both the limbs show considerable symmetry. The structural features are remarkable for their continuity, and great regularity and uniformity of strike and dip is observable over long distances. As a result of varying stresses a system of joints traverses the rocks at a certain horizon. The banded jaspers and ferruginous quartzose rocks are split up into rhomboidal blocks along the planes of fracture, which intersect one another with marked regularity at uniform angles. The various sedimentary rocks of the Sandur area show more or less schistosity. The strata, composed of different sediments, alternate with each other, and in several cases well marked contact planes are present, which serve to indicate bedding. The secondary structure which has been developed in the rocks is parallel to the bedding, and it appears that the lamination in the schist of the Sandur area is due to stratifiication as well as cleavage foliation, which coincide with each other.

(27) Limits and structure.

The basement complex is nowhere exposed within the Sandur band, nor any eruptive granitoid. Just within the westernmost

(28) Rock succession.

boundary of the State, there is a small area occupied by hills composed of gneissoid granite. The western boundary of the Sandur band and its contact with the granitoid gneiss cannot be traced owing to the junction being obscured by great spreads of residuary mantle. The Dharwar rocks of the Sandur area chiefly comprise great thicknesses of a ferruginous gritty schist, phyllites, banded jaspers and clay schists of various composition. This rock series, in the above order of upward succession, constitutes the western arm of the syncline. Thin beds of quartzite are also associated with the gritty schist. Interstratified, contemporaneous trapflows are more or less common in all the principal rocks with the exception of the banded jasper and quartzites. The strata frequently grade into one another vertically and horizontally. While some of the beds retain their lithological character making their identification easy wherever seen, a number of them undergo great changes. The western limb of the syncline is chiefly composed of a series of rocks which constitutes a great manganese and iron ore-bearing formation. An attempt will here be made to describe some features of this rock series.

2.—*Petrological Notes on the Iron and Manganese-Ore-Bearing Formation.*

The principal iron and manganese ore-bearing formation is situated at the base of the banded jasper which shows conspicuous development on the eastern flank of the western arm of the syncline. This member consists of a conformable set of beds, composed of a dark-grey and greenish sandy ferruginous schistose rock, which passes into phyllites, highly ferruginous and manganiferous at

(29) Quartzose, ferruginous slates.

places, and containing alternate bands of manganese and iron-ores. This bed of phyllite is overlain by thick beds of banded jasper, which being the youngest member occupies the highest position in the series. The quartzose ferruginous rock has apparently been subjected to much alteration, which has given rise to different types, the least modified type being probably a hard quartzose rock of dark-grey or greenish hue which partly retains the character of a clastic sediment. This rock is well seen not far from the base of the principal manganese-ore deposit, below the edge of the Ramandrug plateau. There it forms a cliff of considerable height. The rock frequently shows slaty cleavage, the development of which seems to be dependent on the degree of the fineness of the component grains. For when the rock is fine grained, it shows a slaty structure and resembles grey-wacke slate; whilst in the more quartzose phase, the cleavage is not well developed. In places, this quartzose slate grades into fine-grained quartzite owing to the increase of the proportion of quartz and the elimination of clayey constituents. But a more frequent phase of alteration is a highly ferruginous schist in which there is a preponderance of the ferruginous constituents. In the least decomposed type, the rock, under the microscope, is found to consist of irregular grains of quartz of fragmental origin. This is the principal component of the rock mass, which also contains fragments of felspar. Minute flakes of mica are occasionally found in the plane of cleavage, and sometimes chlorite is present as a secondary product. The quartzose matrix contains abundant accumulations of magnetite. Crystals of hematite are also present and, when closely grouped together, lend a steel-grey appearance to the rock. The proportion of felspar and of ferruginous minerals varies in different specimens. Frequently, kaolin has been formed by the decomposition of the felspar and the rock then consists of this decomposition product, which is only subordinate to the quartz as a principal constituent.

The argillaceous schists or phyllites, which are by far the most important member of the iron ore-bearing formation on account of their association with the iron and manganese ore-deposits, show great development on the western arm of the syncline. They are confined between the graywacke slate and the banded quartzites. Although exposed in several localities, they are so much obscured by great laterite cappings and residuary mantle that, at first, their widespread character is not brought prominently to notice. But in spite of this obscurity, it is surmised that their vertical and horizontal distribution are probably equal to, if not greater than, those of the quartzose and ferruginous rocks, which seem to constitute the great bulk of the rocks in the Sandur area. The ore-bearing phyllites are exposed in the vicinity of many of the manganese and iron ore-deposits, which are intercalated between the layers of phyllites. Good exposures of phyllite are also seen in many of the ravines. These rocks are mainly of a somewhat dark red colour owing to the presence of ferric oxide. But there are also gradations from yellow to white. The lamination is well developed in the fine grained varieties, which split into exceedingly thin sheets, the cleavage surfaces of which possess a smooth shimmering appearance. These phyllites[1] are usually soft and brittle,

(30) Argillites.

[1] Professor Kemp in his "Hand-book of Rocks" recommends the use of the term "phyllite." Mr Fermor first pointed out the applicability of this term with reference to the argillaceous schist of the Sandur area. In this paper the term "argillites" has been retained when the schists show marked argillaceous

and are frequently so fine-grained that their exact mineral character cannot be determined. In coarse grained varieties, abundance of quartz grains, mixed with numerous fragments of felspar, can be readily made out as forming the ground-mass. The decomposition of felspar has frequently produced kaolin. Thus the passage of the rock into lithomarge is widespread. Iron oxide, chiefly as magnetite or hematite, can also be detected in the majority of specimens of phyllite. Fine scales of sericite, although not abundant, are invariably present. Manganese minerals are also found in the phyllites in close proximity to the manganese-ore deposits. The argillites are not carbonaceous like those described by Mr. Maclaren in association with the auriferous quartz reefs in the Gadag band. As locally developed, they are conspicuously ferruginous.

(31) Banded jasper.

The banded jasper beds show striking development in the interior of the Sandur basin, where they form great cliffs of vertical and horizontal extension, cresting the upper part of the ridges. These cliffs are most impressive in appearance and the Sandur landscape owes much to their grandeur Important exposures of beds of banded jasper are seen on the north of the Ramandrug plateau, at Hari Sankar Kolla at the foot of the Kumaraswami Valley, on the top of the Devadari Range and Donimalai and below the ancient fortress on the Timappa Range. The gorge beds at Oblagandi and Bhimagandi are formed of great precipitous cliffs of banded jasper. As typically developed, the banded jaspers always occupy a position entirely above the principal iron and manganese ore-bearing formation. The jasper beds contain laminæ of iron ores, but have not

character. Such rocks have been designated as "phyllite" when mica is present in sufficient quantity and when the rock can be split up into thin sheets.

been found to contain any manganese-ore in spite of careful examination.[1] This non-manganiferous member is overlain by various kinds of schistose rocks, which occupy the greater portion of the Sandur valley and are, in their present state, devoid of metalliferous formations. In the typical form, the banded jasper beds consist of alternate laminæ formed by amorphous silica and layers of hematite or magnetite. The width of the laminæ varies greatly. In some specimens, the laminæ of the iron minerals are as thin as paper, being almost undistinguishable from the siliceous laminæ. Further there are all gradations between the almost pure siliceous bands and bands in which iron minerals predominate to the entire exclusion of siliceous laminæ. The coarser banded jasper shows brilliant alternating thin bands of iron oxide of various shades of red and yellow colour and of iron stained jaspideous quartz. The iron oxide is mainly present as red hematite and specular ore and also as magnetite and micaceous hematite in subordinate proportion. Hydration of the ferruginous layers has also resulted in the production of limonite in some places. The interstices between the laminæ of hematite are frequently seen to contain minute brilliant spangles of hematite produced subsequently by infiltrating solutions. These crystalline aggregates can be easily identified from original sheared lustrous micaceous hematite produced by readjustment of the layers of the iron oxide during dynamic movements. The origin of the banded jaspers as developed in the Sandur area is problematical. It may be suggested that they are altered ferruginous quartzose slates

[1] A black powdery mineral occurs in association with the banded jasper. This was mistaken for an ore of manganese. But analysis has proved its ferruginous character.

in which rearrangement of iron oxide and silica has taken place during folding. Subsequent introduction of silica and iron oxide, deposited parallel to the lamination from extraneous sources, has emphasized their banded structure.

(32) Correlation.

The similarity of the members of the Dharwar system with those of the Huronian group in the Lake Superior region was long ago pointed out by M. Emm. de Margerie. The lower series of the Original Huronian of Logan and Murray bears considerable resemblance to the rocks of the Dharwar type in the Sandur area, which can be correlated to some extent with the lowest series of Algonkian system of the Lake Superior region, which belongs to the Lower Huronian and consists of closely folded limestones,[1] quartzites, micaceous schists, ferruginous and jaspery beds and masses of interstratified greenstone and chloritic schist. In the absence of palæontological evidence, the correlation is based upon lithological similarity of the pre-Cambrian clastics and upon the effects of the great dynamical movements to which they had been subjected. An attempt to correlate formations, in widely separated regions, on lithological resemblances only, is liable to error. Opinion also differs as to the grouping of the Dharwar rocks. The delimitation of the Dharwar system and the Archæan rocks may be based on the unique complexity of the lithological character of the latter, which is wanting in the Dharwar

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1 The author has not been able to locate a single bedded occurrence of limestone in the Sandur area. A few thin veins of calcite and concretionary deposits of calcium carbonate exist. In this respect, the Sandur band offers a strong contrast to the other Dharwar bands, in some of which beds of crystalline limestone attain conspicuous development, a feature, perhaps, not without bearing on their relative age.

rock. Vredenburg[1] differentiates the Dharwar rocks from the Archæan under which he includes only the basal crystalline complex to the exclusion of all clastic rocks and their crystalline equivalents. This classification is at variance with that proposed by Sir Thomas Holland,[2] in his inaugural address to the Mining and Geological Institute of India, in which the Archæan group, besides the crystalline complex, embraces the Dharwarian Rocks which are considered as equivalents of the rocks of the Huronian age but older than those of the Algonkian group. This total exclusion of the Huronian from the Algonkian appears to be opposed to the conclusion arrived at by Van Hise and other American authorities on the subject.[3]

IV.—DISCOVERY AND LOCATION OF THE MANGANESE-ORE DEPOSITS.

1.—Pioneer Work—purely Geological; Consequent Limitations.

(33) Newbold's estimate of deposits discovered by him and inference therefrom.

It has already been stated that Newbold, although he has recorded the existence of manganese-ore in the Sandur State, did not specify any locality where he noticed such an occurrence. That no important deposit was discovered by him may be inferred from a

[1] Ernest E. Vredenburg, A.R.S.M., A.R.C.S.,—" A summary of the Geology of India " (1907).

[2] T. H. Holland, F.R.S.,—" Presidential Address "—Transactions of the Mining and Geological Institute of India, vol. i., part i, p. 47.

T. H. Holland, F.R S.,—Chapter on " Geology " in the Imperial Gazetteer of India, vol. i., pp. 58-61 (1907).

[3] Since writing the above, the author has come across the following passage in Sir Thomas Holland's recently published " Sketch of the Mineral Resources of India," where, referring to the Dharwar system, he says that " Lithologically,

statement contained in his classic "Summary of the Geology of Southern India." He states that "the black oxide of manganese, associated with iron ore, is found in considerable quantities among the Kupputgode Hills and more sparingly in those of the Ceded Districts, Mysore and Nilgherries."[1] In the light of recent investigations, the Kupputgode manganese-ore occurrences seem to be insignificant and in describing them, Dr. Maclaren observes that "manganese occurs in small quantities."[2] Since the Kupputgode deposits are small, it may be presumed that those noticed by Newbold in the Sandur area, which is included within the Ceded Districts, were still smaller.

(34) Foote's discoveries confined to minor deposits.

Foote discovered only four localities and the ore was found to occur as nodules. As he considered the Kanevihalli occurrence the most promising, and as the largest nodule found by him was of the size of a "child's head," it may be concluded that he did not come across any of the principal deposits, numbering nearly one hundred, discovered by the author and which form the subject of this paper. The great stress which Foote lays on the magnitude of the iron-ore deposits of the Sandur State proves conclusively that if he had been aware of the existence of large deposits of manganese-ore, his description would not have been confined to insignificant occurrences of this ore.

and in its stratigraphical relationships, this group of rocks corresponds approximately to certain of the so-called Algonkians of the United States, and to some of those classed as Huronian in Canada."

[1] Journal of the Royal Asiatic Society, vol. viii, p. 155.

[2] J. Malcolm Maclaren, B.Sc., F G.S.,—" Notes on some Auriferous Tracts in Southern India " in the Records of the Geological Survey of India, vol. xxxiv, p. 128.

(35) Exterior appearance of the Sandur manganese-ore deposits deceptive.

The above remarks may be considered as unnecessary and as a digression on the part of the writer, or may be construed otherwise. But as questions have been repeatedly asked as to the discovery of the Sandur deposits, it may be permissible to clear up the obscurity. The Sandur area, as already stated, was the subject of geological investigation by such a high authority as Newbold in the middle of the nineteenth century. Later, the area was fully described by an eminent geologist like Foote, who paid more than one visit to the area. Naturally the question arises, and has often been asked: how was it possible for these observers to leave unnoticed the large number of main manganese-ore deposits discovered by the present writer? The solution of this question is simple. In all probability, the above geologists had no occasion to traverse the ground in the immediate vicinity of the ore-deposits. If it had been otherwise, the manganese ore-deposits which are so well developed could not have escaped their keen observation. There is another point which may be mentioned in this connection. Several of these deposits are situated just on the edges of the plateaus, and in many cases they are covered by a heavy residuary mantle or a capping of laterite, which obscures the view so much that, unless one descends from the edge of the plateau, there is little chance of finding the majority of the deposits, which are situated just where the slope begins, below the plateau escarpment. Even then, one has to contend with the dense growth of Lantana, the tall lemon grass and the brushwood, unless one visits the area during the summer months. Moreover, the surface of the deposits is in many cases so coated with a ferruginous stain that only experienced eyes can penetrate through the deceptive appearance. Those who have seen only the unmistakeable black outcrops of manganese-ore in the Central Provinces will hardly be able to identify a Sandur ore-bed at first sight, as the outcrops frequently present an appearance which is liable to be mistaken for that of a ferruginons ore-body.

(36) Evidence as to general lack of interest in minerals in India.

A noteworthy instance of failure to recognize the manganese-ore outcrops in at least one locality may be cited here. The plateau of Ramandrug has been utilised as a sanitarium for the British troops since 1846. The barracks have been built actually on manganese-ore deposits and there are conspicuous outcrops of ore near the cemetery and below the Fives Court. A cave, immediately underlying the barracks, has been used for several decades as a resort for the soldiers and more than one visitor to it possessed scientific knowledge. This natural cave is bounded on all sides with masses of manganese-ore which forms a bed of some importance. But strange to say, this deposit remained unnoticed and unidentified till 1905, when the present writer came across it, in the course of his exploration.

(37) Recent discoveries—how they originated.

It is impossible for the author of this paper to pass by this subject without acknowledging his indebtedness to the original discoveries of Newbold and Foote. While perusing Newbold's paper on "A cursory Notice of a Gold Tract in the Kupputgode Range—Manganese Mines near Woodoorti, etc.," he first learnt of the existence of manganese-ore in the Sandur State. As he was interested in this mineral, it led to a search for further information in the publications of the Geological Survey of India which resulted in the study of Foote's historical researches on the Dharwar system.

From Foote's "Memoir on the Geology of Bellary District," the few manganiferous localities then known in the Sandur State were ascertained. At the same time the writer was struck with the magnitude of the iron-ore formations of the Sandur State and as he assumed, rightly or wrongly, an intimate relationship between iron and manganese-ores in the Dharwar rocks, he was led to infer that the precipitation of an immense quantity of iron-ore in the Archæan Ocean, which once extended over the Sandur area, was not probably unattended with the simultaneous local formation of considerable deposits of manganese minerals. This assumption was the result of previous observations on the association of iron and manganese-ores in the Dharwar rocks, in another part of India. Hence the inference as to the probable occurrence of large deposits of manganese-ore in the Sandur area, where the iron-ore beds and the associated rocks were known to be conspicuously developed, was not entirely without a basis or parallel.

2.—Preliminary Investigation.

(38) Relocation of Narain-Devarkera Ghat Road deposit.

Towards the end of 1903, the author of this paper brought the manganese-ore occurrences recorded by Newbold and Foote to the notice of Mr. Charles Aubert of Messieurs Jambon and Cie., and after some difficulties so far succeeded in interesting him that two men were sent by the writer to bring specimens of ore from these localities and to ascertain the extent of these occurrences as far as their limited knowledge permitted. They were able to trace the nodular deposit on the hill road on the western slope of Ramandrug Ridge. Owing to the stringent rules, adopted by the authorities at Sandur, prohibiting the access of outsiders within the State limits in order to prevent the introduction of plague, then prevalent in the adjoining British Territory, the endeavours of these men to reach the other manganese-ore localities previously reported were frustrated and further search was discontinued.

(39) Unsatisfactory results.

The specimens brought from Ramandrug had a nodular structure and earthy character, and gave exceedingly poor analytical results, which confirmed the analysis of Mr. Phillip Lake quoted by Foote. This was sufficient to seal the commercial possibility of these deposits and led to the abandonment of further investigation. But the author of this paper was unable to accept these conclusions as to the non-existence of manganese-ore deposits of economic importance as final, and he arrived at Ramandrug in the beginning of February, 1905, to satisfy himself on the point.

3.—Exploration and Discovery of the Principal Manganese-Ore Deposits.

(40) Discovery of the Ramandrug main Bed.

On his arrival at Ramandrug, the author of this paper set out to find the Naraindevarkera Ghat road deposit of manganiferous nodules originally discovered by Foote. This road leads from the top of the plateau to the foot of the hill, by a winding course extending over three miles along its western flank, and to Mariamanhalli and Naraindevarkera villages in the plain. The ghat road deposit was easily located by noticing a distinct change in the colour of the road material, which from an ochreous red, assumed a blackish hue, due to the presence of innumerable particles and pieces of manganese-ore in the paving material. The road has been excavated in the hill side and is bounded on one side by rocks which are exposed in the cuttings. Close to where a change in the colour of the paving material was discovered, there is a good exposure of rocks, which shows at places an intensely black manganiferous stain and also variegation in the colour of the schist owing to weathering influences. At places, alternate thin bands of manganese-ore and a highly decomposed schist are so prominent that they cannot fail to attract attention. Further down, the layers of manganese-ore give place to small nodular concretionary pieces imbedded in the schist, as described by Foote. This manganiferous formation, exposed in the road cutting, did not appear to be of any economic importance. But the nature of the deposit and its alternation with the schist led to a supposition that this exposure on the hill slope was possibly the remnant of a larger deposit and represented impoverishment in the lower portion, where the layers of manganese-ore gradually became barren and merged into the schist. Exploration of the hill slope immediately above this cutting was followed by the finding of a large boulder of manganese-ore weighing several tons. The size and structure of the boulder, which at places distinctly showed lamination, hardly left any doubt that it was not improbably dislocated from a large deposit. But the slope of the hill was so thickly overgrown with Lantana and brushwood that the writer was compelled to abandon the search from this side of the hill, after vain endeavours to penetrate through the jungle. The next day, an attempt was made to descend the slope from the top of the plateau. But the task was equally difficult and resulted in going in the wrong direction. However, this attempt was not fruitless as it led to the finding of an immense accumulation of manganese-ore boulders of large proportions on the western slope, which was thickly covered by the boulders for a length of nearly one-eighth of a mile. These blouders left no doubt as to the occurrence of a large deposit and after two days' continuous exploration the so-called "main bed" of manganese-ore, near the "Prospect Point," was located by the writer and amply justified his expectation as to the existence of large deposits of ore. This deposit formed a cliff (which exhibited bedded character) of manganese-ore projecting from the top of this portion of the hill, the slope of which was studded with boulders. The cliff maintained a height of 26 feet for a distance of nearly 150 feet. The deposit was traced for a length of 600 feet, the height of the exposed bed being nowhere less than 6 feet. It must be stated here that the face of the cliff, where it attained the maximum height, presented such a ferruginous appearance that the writer had every chance of being misled into taking it for a ferruginous body. But the breaking of a few pieces disclosed a hard, compact psilomelane, with bluish tinge, containing crystals of pyrolusite. After the discovery of this deposit, further exploration of Ramandrug Hill was temporarily deferred and the writer proceeded to examine the occurrence at Kanevihalli, previously reported on by Foote.

This locality was not so easy of identification as the Naraindevarkera Ghat Road occurrence, as Foote merely mentioned that the nodules occurred on the western flank of a small spur two miles south of Kanevihalli. As the name of the hill was not given, and as there are many small spurs two miles south of Kanevihalli, it took some days to identify Foote's locality, which was probably Hulibasappan Maridi. But the author is by no means certain as to this identification as on the top of this hill there are several boulders with which the size of a "child's head" cannot bear proper comparison. None of the other spurs about two miles south of Kanevihalli, where the writer observed the occurrence of manganese-ore, agreed with the description of Foote's locality, as all the occurrences located on the slopes of Mottu-Kolla were found to be immense accumulations of huge boulders of manganese-ore, some of them weighing over twenty tons at a moderate estimate. The location of the main deposits from which these boulders were derived, was left for a future date, and the writer turned his attention to the two other localities in the south of the Sandur State discovered by Foote.

(41) Location of Kanevihalli talus ore-accumulations.

To reach these localities with expedition, it was necessary to cross the great southern plateau known as Kammat Haruvu. A cart road leads from Sandur to the foot of Kammat Haruvu Hill. The ascent of the hill was accomplished by a rugged foot-path. It was the intention of the writer to halt on the top of the plateau and to examine the iron-ore deposit, reported on by Foote, before proceeding to Tonashigiri. Just before the top of the plateau was reached, the writer was struck with the appearance of the boulders in a long line of wall, built apparently as a sort of primitive fortification. As he had previously observed the utilisation of boulders of manganese-ore for constructing enclosures for roadside plants near Gitilpi village, in the neighbourhood of Chaibassa, in the Singbhum District, Bengal, the black colour of the boulders of the wall led him to test its nature and it was found that the boulders consisted of manganese-ore. This

(42) Discovery of Kammat Haruvu outcrops.

was followed by a search in the vicinity and enormous outcrops of manganese-ore, stretching far and wide on the plateau, were discovered without much trouble, as the plateau was bare of vegetation and did not present the difficulties encountered at Ramandrug.

The clue, supplied by the wall of manganese boulders, led to the finding of the extensive outcrops of Mariman Banda, Danada Turumendi Banda, Nagappana Banda, Galay Banda, Ellakal Gadday Banda and Badapatti Banda. These outcrops protrude through the alluvium of the surface of the plateau near the Kammat Haruvu village and the cultivated lands. Nearly all the outcrops strike in a N.-W. direction and present a banded appearance, some of the bands being parallel. By following the strike of the elongated manganese-ore band known as Galay Banda,

(43) Discovery of the southern deposits.

the writer came across the extensive manganese-ore deposits in Durgamma Kolla on the southern edge of the plateau. Standing on the top of the westernmost outcrop of Durgamma Kolla, one could see a succession of immense bands of manganese-ore running from spur to spur. The writer could not help arriving at a conclusion as to the existence of a distinct ore-horizon. Whether he was correct in supposing that a series of manganese-ore bands, extending from spur to spur, swept along a definite horizon, along the flanks of the hill ranges forming the Sandur syncline, is a matter of controversy. But it must be stated that the discovery of a large number of extensive manganese-ore deposits on the Sandur Hills, within a short time, was essentially due to this conception—rightly or wrongly based—of a definite ore-horizon, which was bounded on one side by a peculiar gritty schist, first found as forming the foot-wall of Ramandrug main bed and again detected at Mala Kolla Banda, Jaldi

Kolla deposits, etc. The writer was thus enabled to locate the southern deposits, comprising Hunasemarad Kativi, Kanakeri Wadai, Yerin Dari, Jogannaaditha Kolla Kativi, Durgamma Kolla Banda and Kativi, Kenchamon Doni, Karadi Badsala Kativi, Chitra Devar Gudda, Jaldi Kolla, Mala Kolla Banda, Janal Haru, etc.

Attention was next directed to the exploration of the isolated plateau, west of Kammat Haruvu. Here also a series of deposits were located as well as on the south of Kumaraswami Hill plateau and on Subrayanhalli plateau. After an interval of a few months the exploration of the Ramandrug and the Kanevihalli Ranges was continued and several extensive deposits were located.

(44) Location of deposits on Kumaraswami Kanevihalli and Ramandrug ranges.

4.—LOCAL NAME FOR MANGANESE-ORE.

It has been said that the Canarese name for manganese-ore is "Ukkina Kallu" and it has even been suggested that this is the name orginally applied to manganese-ore by the local people. The above assertions, in the opinion of the author of this paper. are without foundation. So far as his investigation goes, he is satisfied that the Canarese inhabitants of the Sandur State had no distinctive name for manganese. Before the starting of the manganese mining operations, the ore was not considered as of any economic importance or as metalliferous. From enquiries made of the villagers of Kammat Haruvu, Kanevihalli and Dharampur, who were engaged in smelting iron-ore on a considerable scale in the primitive way, it was elicited that they always regarded the ores of manganese as of no use and termed it 'Kattay-Kallu,' *i.e.*, useless stone. It was also ascertained that some of them, struck with the high

(45) Manganese-ore not recognised by the inhabitants as of economic importance.

specific gravity, tried to smelt the ore, but did not succeed in their attempts. It may be mentioned here that the word 'Kattay' is also a Canarese metallurgical term used to signify refractory ore. On enquiry whether the term was used in this sense with respect to manganese-ore, the reply was in the negative, and it was evident that manganese-ore was called 'Kattay Kallu' because it was considered to be a useless rock and not an ore. The only name by which manganese was known to the Boyas and other Canarese-speaking people was 'Kare Kallu' meaning "black stone," and this was by no means confined to manganese-ore, all rocks black in colour being included under this name.

(45) Origin of "Ukkina Kallu."

It was after the opening of the manganese mines, when the labourers and others had come to learn that the ore is used in the manufacture of steel that a limited number of them adopted the name "Ukkina Kallu" ("steel stone"), and there is no ground for stating that the ore was originally known by this name or that the local people were aware of its utilisation in indigenous manufacture of steel. It may be mentioned that among ignorant people there is a belief that silver is extracted from the Sandur manganese-ore. This curious notion had its origin in the export of the ore to foreign countries in the raw state, and in the heavy expenditure incurred in working the deposits.

5.—List of Manganese-Ore Deposits in the Sandur State and in the adjoining British Territory.

(47) Names of Manganese-ore deposits.

Before enumerating the localities where manganese-ore deposits occur in the Sandur State, and in the British Territory immediately adjoining it, it may be explained how the deposits have been named. It has already been noted that all topographical features in the Sandur State have been endowed with distinctive names by the Boyas, and it is not surprising that many of the outcrops of manganese-ore which attracted their attention by their prominence have been endowed with different names. It must not be supposed that the Boyas used special discrimination in naming only the manganese-ore outcrops or that they distinguished these from any other rocks. Like all other rocks which formed prominent features in the landscape, any manganese ore-body or boulder was given a name for facilitating identification of neighbouring places, for reconnoitring, or hunting, or other purposes. There is also a large number of manganese-ore deposits which have not been named by the Boyas. Instead of giving some fanciful names, as is usual in many mining districts, the writer has retained the names of hills, ravines and plateaus, etc. in the immediate vicinity of these deposits, so that they may be relocated easily.

(48) Derivation of names.

It will not be out of place to mention the origin of some of the curious names attached to outcrops and boulders of manganese-ore. A huge boulder of manganese-ore weighing several hundred tons, in Durgamma Kalla, is known to the villagers of Kammat Haruvu as "Kardi Gundu" (Bear Boulder). It is said that this name was given to the boulder, as several years ago this was a favorite resort of bears. Another massive boulder close by is known as "Pilal Marad Gundu," as Pilal trees (*Ficus retusa*) grow near it. A large outcrop of Kammat Haruvu has been named Nagappana Banda to commemorate the name of Nagappan, a man of some importance in former times. The cliff-like exposure of "Tambala Naikan Padi" derives its name from the fact that in old turbulent times, a chief named Tambal Naikan took refuge in the cave in the manganese-ore bed. "Doni Bandi"—a flat outcrop on Hanumanthan Haruvu is so called because there is a water hole ('Doni') in it. A banian tree is responsible for the name of the outcrop known as Ald Marada Banda. These are typical examples of the peculiar names attached to manganese-ore outcrops and the names have been selected by the Boyas with reference to mythological, historical, zoological or botanical associations, as in the case of the hills, ravines, etc.

(49) Canarese terms for outcrop and boulder.

An instance of the discriminating power of the Boyas may be mentioned here. They have recognised the difference between boulders and bedded rocks to a surprising degree. The boulders are called "gundu" and the outcrops "banda."[1] There are only a few instances where actual outcrops have been mistaken for boulders; this is primarily due to the appearance of the outcrops which assume a boulder-like shape. The bedded outcrops, known as Kanevihalli Budhana Gundu and Mannal Haru Budhana Gundu, which form huge isolated prominences, have been called "gundu" as they present boulder-like appearance. On the other hand, there are some boulders of manganese-ore which are liable to be mistaken for bedded deposits. But the Boyas have successfully identified them as boulders. The dislocated ore-bodies known as 'Pilal Marad Gundu,'' which are liable to be mistaken for a bedded deposit, form an example of this class.

(50) List of localities containing manganese-ore deposits.

The following is a list of the manganese-ore deposits of the Sandur State and in the British Territory immediately adjoining it. In enumerating the localities, the

[1] Banda is also applied to slabs of rocks.

deposit situated on the easternmost portion of the Kammat Haruvu Plateau, has been made the starting point.

I.—KAMMAT HARUVU GROUP.

1. Pam Kolla Tatttu.
2. Kebbana Govi Tattu.
3. Mariman Banda.
4. Danada Turumendi Banda.
5. Galay Banda.
6. Nagappana Banda.
7. Ellakal Gadday Banda.
8. Maleva Gadday Banda.
9. Badpatti Banda.
10. Karai Marad Banda.
11. Hunasemarad Kativi.
12. Kanakeri Wadai
13. Yerin Dari.
14. Joganna Aditha Kolla.
15. Doni Banda.
16. Onnay Marad Gadday.
17. Buman Gadday.
18. Kattedar Bylu.
19. Neer Kolla Banda.
20. Alada Marad Banda.
21. Durgamma Kolla Banda
22. Karadi Badsala Kativi.
23. Kenchaman Doni.
24. Jaldi Kolla.
25. Chitra Devar Gudda.
26. Yerra Guddina Kare Kallu
27. Mala Kollatha Banda.
28. Janal Haruvu.

II.—HANUMANTHANA HARUVU GROUP.

29. Hanumanthana Haruvu Deposits.
30. Doni Banda.
31. Hanumanthana Kativi.
32. Patargani Muli.

III.—TONASHIGIRI FOREST GROUP.

33. Pilal Marada Gundu and Kaldi Gundu.
34. Agasar Tattu.
35. Kalhatti Marad Tattu.
36. Sankara Tattu.
37. Joga Muttian Halli Mutty.
38. Kallay Kativi.

IV.—MANNAL HARUVU GROUP.

39. Mannal Haruvu Banda.
40. Gadigal Tattu.
41. Ram Kolla.
42. Nagappana Penta.
43. Budhana Gundu.
44. Tamba Naikan Paddi,
45. Girenath Kolla.
46. Basiri Marad Yennu.
47. Swamihalli Turumandi Banda.
48. Basiri Marad Kativi.

V.—KUMARASWAMI GROUP.

49. Chinna Budhana Gundu Kativi.
50. Sillu Kolla Kativi.
51. Bandijadi Kativi.
52. Errakan Mulay.
53. Badial Marad Kativi.
54. Yello Suttina Haruvu.
55. Tappal Paddi and Hulisutta Banda.
56. Bundar Banda.

VI.—SUBRAYANHALLI RANGE GROUP.

57. Subrayanhalli Plateau Deposits.
58. Chennangi Marad Kolla.
59. Kanegina Marad Kolla.
60. Karadi Kolla.
61. Thareard Marad Kolla.
62. Subrayanhalli Neer Kolla Kativi.
63. Kapatswami Kolla.
64. Nawalswami Kativi.

VII.—TUMBARAGUDDI FOREST GROUP.

65. Subrayanhalli Neer Kolla Banda.
66. Halli Marad Doni.
67. Jiginhalli Mannu Tippa.

VIII.—KANEVIHALLI RANGE GROUP.

68. Dumku Neer Kolla.
69. Boki Kolla.
70. Iruku Kolla.
71. Hatti Penta.
72. Mudiki Thaggu.
73. Budhana Gundu.
74. Alada Marada Banda.
75. Mottu Kolla Kativi.
76. Ganigithi Kolla Kativi.
77. Motto Kolla Haruvu.
78. Achchu Kolla.

IX.—RAMANDRUG RANGE GROUP.

79. Meen Kolla.
80. Ager Gundi.
81. Gedel Tattu.
82. Shesh Giri.
83. Neer Kolla.
84. Kadlekan Haru.
85. Karadi Kolla.
86 Baray Marad Dinne.
87. Donay Kolla.
88. Janay Kal Haru.
89. Mat Kolla.
90. Ald Marada Haru.
91. Fortwall Deposit.
92. Deposit near the Cemetery.
93. Deposit below the Barracks.
94. Deposit near Hospet Road.

95. Ramandrug Plateau Deposits.
96. ,, Main Bed.
97. Mavin Marad Kolla or Ramandrug cave deposits.
98. Kurubara Mutti.
99. Sanna Sil Haruvu.
100. Ettimar Kolla.
101. Kalhalli Gudda (British territory).

X.—TIMMAPPA GUDDA GROUP.

102. Herai Gungadi.

In the above list of localities, comprising over one hundred manganese-ore deposits, the boulder beds at the foot of Gedel Tattu Haruvu, Mottu Kolla, Aldmara Kolla, Hulibasappan Maridi and at numerous other localities have not been separately mentioned. Only the deposits which form actual outcrops have been listed. The inclusion of Pilal Marad Gundu and Kaldi Gundu, which are boulders of enormous size, is based on the fact that they are associated with outcrops in the immediate vicinity. With this exception, the other deposits in the Tonashigiri Reserve are unimportant. It may also be noted that many of the localities, listed above, contain more than one distinct deposit, lying close to each other. The list shows only the different localities where manganese-ore deposits occur without any reference to the number of individual deposits. Each locality contains at least one deposit.

V.—DESCRIPTION OF THE ORE DEPOSITS.

I.—KAMMAT HARUVU GROUP.

(51) The plateau.

The plateau locally known as Kammat Haruvu, in the south of the Sandur State, bordering on the Tonashigiri Forest Reserve in the British territory, is by far the broadest expanse of land crowning the summit of the Sandur Hills. Its shape is irregular. With the exception of the great hematite outcrop of Muli Harivi Gutti, which rises to a height of 215 feet above the plateau, there are no other prominences and the surface of the plateau is almost level, only at a few places showing an undulatory character. Towards the north, the plateau overlooks the banded jasper cliffs of the Devadari ridge and the wooded ravine known as Katari Timman Kolla. Towards the north-west, it is connected by a narrow neck with the Malliam Haruvu. On the west, the plateau is cut off by the great ravine known as Hunasimarad Kolla and by Sandur Marad Kolla. On the south, it is bounded by Joganna Aditha Kolla, Durgamma Kolla, Jaldi Kolla and Appianhalli valley, while towards the north-east and east, it overlooks the synclinal valley which, on the east, is bounded by the Doni Malai. The plateau is the result of the relative uniform erosion produced on the summit of the south-easterly continuation of the hill range forming the western arm of the syncline. Except on the edges, it is bare of forest growth. The surface of the plateau is covered by a wide stretch of red loam which obscures the underlying rock formation. The remainder of the plateau is occupied by large exposures of phyllites, mantled extensively by cappings of laterite. In the centre and on the western and southern parts, immense outcrops of hematite and manganese-ore are conspicuous and cannot escape the notice of even casual observers.

(52) Pam Kollatha Tattu.

Ascending the hill of Kammat Haruvu by the foot-path which passes in close proximity to Kataritimman Kolla, one crosses in succession exposures of contemporaneous trap flow, yellow and variegated phyllite, banded jasper, red phyllite passing at places into limonite, and highly ferruginous phyllite. The last give place to laterite and brecciated and pisolitic limonite beds, which form a horizontal capping on the northern fringe of the plateau. Towards the left of the foot-path, there is a great development of the lateritic crust. This culminates in a cliff-like exposure of enormous blocks of laterite, which overlook the ravine known as Pam Kolla. At places the laterite is highly manganiferous. Below, it gives place to a large vertical exposure of manganese-ore which is locally called Pam Kollatha Tattu. It is evident that this is the remnant of a large manganese-ore deposit which has been eroded away during the sculpturing of the adjoining valley. There are huge boulders of manganese-ore on the slope. The ore contains abundance of pyrolusite and this deposit appears to be promising. Further prospecting may lead to the finding of a considerable extension of the ore-body underneath the capping of laterite.

About a hundred yards from Pam Kolla Tattu and immediately behind the wall, built of manganese and iron ore boulders, on the surface of the plateau, there is a prominent outcrop of manganese-ore which takes its name from a banyan tree (Mariman-Telugu equivalent for banyan tree—' Ficus Bengalensis '—of botanists). It grows in close proximity to the main outcrop, which has a rounded appearance similar to an imbedded boulder. There are also several small detached outcrops which belong to the same deposit. The deposit, at first sight, appears lenticular in shape. The ore is hard and chiefly consists of psilomelane. Close to this deposit there is a large breccia

(53) Mariman Banda outcrop.

bed composed of angular pieces of limonite imbedded in a ferruginous and alluminous cement. Some blocks show numerous pisolites of limonite which gradually pass into compact, massive limonite.

About two hundred yards south of the 'Mariman Banda' deposit, the first indication of a series of extensive outcrops appears at "Danada Turumendi' or the halting ground of the village cattle. These flat elongated outcrops run parallel to each other and cover a length of nearly five hundred feet along the strike, which is in the north-west direction. Mariman Banda is probably the continuation of this deposit. The outcrops being detached and the intervening ground being greatly obscured by residuary mantle, their exact relationship cannot be established without prospecting work. The outcrops appear prominently on the surface of the plateau, towards their southern extension, where they show a banded appearance and rise to a height of three to five feet above the ground. Here one of them covers a length of 185 feet This outcrop is frequently capped with laminated and compact hematite which is probably of secondary origin. Some of the cavities in the ore-bed contain pisolitic iron-ore. The ore, as seen in the outcrops, has an exceptionally rich appearance being mainly composed of psilomelane with abundance of pyrolusite pseudomorphous after manganite. This is one of the richest and most extensive deposits in the Kammat Haruvu area.

(54) Danada Turumendi Banda.

About four hundred yards south-east of Danada Turumendi, another mass of manganese-ore, almost level with the surface of the plateau, crops out. This is known as Nagappana Banda. The outcrop strikes in N.W. direction. Its maximum length is 400 feet and breadth 71 feet. The ore is of the same character as that of Danada Turumendi deposit. The outcrop shows in one part a superficial encrustation of hematite. The south-western extension of this deposit is partially obscured by a ferruginous capping and the deposit again appears after an intervening space of 430 feet. This portion of the outcrop, which forms a large prominence rising to a height of 3 feet above the ground, is known as Galay Banda. It is traceable continuously for 650 feet along the strike. The breadth is 40 feet. A band of phyllite passing into red hematite runs parallel south-west of the deposit of manganese-ore, which has a banded appearance This band runs parallel to another manganese-ore band known as Badapatti Banda. Galay Banda is remarkable for the uniformity of the quality of the ore, which contains abundance of silky pyrolusite. Towards the south-east, the band disappears under the alluvium. Its extension under the cultivated lands was proved for a distance of nearly two hundred feet by a series of test pits sunk at intervals. Manganese-ore of good quality was disclosed in all the pits. However, the continuation of the deposit further south is problematical.

Another series of manganese-ore outcrops is traceable on the west of the group described above. The most northerly of these forms a small outcrop at a distance of about three hundred yards west of Nagappana Banda. This flat outcrop is surrounded on all sides by ferruginous capping chiefly of lateritic origin. This laterite, although of high level origin, presents the character of the low level type, being composed of pisolites and concretions of limonite embedded in a ferruginous paste. At places, the laterite also contains pebbles of manganese-ore, chiefly composed of pyrolusite with silky lustre, derived from adjacant deposits. Small irregular concretions of the same mineral are also present. This latter formation is due to segregative action. The Yellakal Gadday outcrop shows banded appearance

(56) Yellakal Gadday.

and schistose structure. Its southern extension is obscured by a thin crust of residuary mantle. The mineralogical character of the ore of this outcrop is dissimilar to that of the outcrops of the eastern group of deposits described above. The ore is chiefly composed of compact bluish psilomelane containing numerous minute crystals of braunite, the facets of which present a glittering appearance. The proportion of pyrolusite is subordinate to that of braunite. The ore of the deposits which form this western group is characterised by the presence of braunite with a small proportion of pyrolusite and by its superior hardness—a quality frequently wanting in the softer ores of the eastern group of deposits owing to the preponderance of pyrolusite.

(57) Badapatti Bandi.

Under the name of Badapatti Banda, a number of (probably) detached outcrops mark the southern extension of the Yellakal Gadday outcrop. The combined surface exposure of these outcrops is probably only second in extent to that of Hunasay Marad Banda among the plateau deposits. In all five manganese-ore outcrops are visible but their relationship cannot be established without prospection work. Although they present isolated appearance, owing to the ramifications of the ferruginous capping which surround them completely, it is probable that they belong to two parallel deposits. Their continuity is obscured by cultivated lands. Two of the outcrops are specially remarkable for their wide extent. One of these shows a continuous surface exposure of 300 feet in length and 107 feet in width, while the other is 225 feet long and 104 feet broad. These outcrops are level with the surrounding ground. The ore appears to be rich and possesses marked similarity with that of Yellakal Gadday deposit This is one of the most important deposits on Kammat Haruvu.

Following the strike of Badapatti Banda deposits in the south-south-easterly direction, at a distance of nearly three furlongs, another very extensive deposit is reached, bordering on the edge of the plateau over-looking the deep ravine known as Hoonasay Marad Kolla.[1] The northern portion of this deposit is known as Chintamon Banda and is composed of three slightly detached outcrops probably forming part of the one and the same deposit. The east-south-east outcrop is the largest among the three having a length of 250 feet, and height 9 feet maximum on the western edge of the plateau. Besides these, there is another outcrop which runs along the edge of the plateau for a length of 600 feet. This is the largest exposure. It strikes in a N.-N.-W. direction. This outcrop has an average height of 4 feet above the plateau. The depth cannot be ascertained. This rich band narrows to a thickness of 82 feet towards its south-south-eastern extension where it ends abruptly, being cut off by erosion. The whole outcrop has been split up into rectangular sections by joint planes at right angles to the strike. The entire length of the continuous exposure of all the outcrops forming Hoonasay Marad Kativi deposit is 909 feet. This deposit ranks among the largest in the Sandur area.

(58) Chintamon Banda and Hoonasay Marad Kativi.

To the extreme south-western corner of the edge of the plateau, about three furlongs from the end of the Hoonasay Marad Kativi outcrops, is situated a small band of manganese-ore which has been named 'Kanakeri Waday.' This is one of the smallest exposures among the southern group of deposits. On the top, it is traceable for a length of 50

(59) Kanakeri Waday.

[1] The ravine takes its name from Hoonasay Marad or tamarind tree (Tamarindus Indica), formerly a prominent object in the landscape.

feet and following the strike on the N.-N.-E., it dips under a heavy lateritic capping. In outward appearance, the ore is extremely decomposed and thick encrustations of limonite and laterite are visible so that the ore presents a honeycombed and brecciated appearance. This impoverishment is only superficial, as is seen in the south-south-western end of the deposit, where the ore is of fair quality and contains a large proportion of pyrolusite and altered manganite. This deposit, which shows banded character, has been split up into two parts just below the edge of the plateau. The dislocated portion rests as a boulder at the foot of the cliff-forming deposit. This boulder weighs over 300 tons. Besides it, there are several boulders on the slope of the hill.

60) Yerin Dari deposits.

Unlike Kanakeri Waday, the Yerindari[1] portion of the plateau containing the manganese-ore deposits does not show any iron outcrop. There are only a few boulders of brecciated manganiferous hematite. On the hill slope at the base of the deposits, there are large exposures of a highly ferruginous phyllite which at places has been altered into concretionary iron-ore. The outcrops on Yerin Dari may be divided into three groups. Of these, the manganese-ore deposit on the southern edge of Yerin Dari can be traced continuously without interval for 950 feet. The northern and the southern extension of the Yerin

[1] Yerin Dari or "way of pack bullocks" is the name given to a promontory on the south of the plateau. It has been so named because originally the foot-path to Tonashigiri village at the foot of the hills and to British territory traversed this promontory, and ochre and iron ore used to be carried on pack bullocks by this route. Pieces of granite are still to be found along these abandoned tracks, and these have been known to puzzle at least one geologist who was unaware that they were brought from the adjoining granite area to equipoise the loads on the pack bullocks.

Dari bed have been eroded and removed during the excavation of the valley on either side. The end exposure on the southern flank presents a striking appearance, the bands being fractured across the strike and conspicuous as huge columnar masses lying almost horizontally and close to each other. Although it appears that the Yerin Dari beds do not attain great depth, yet the quantity of ore available is very large and can be estimated at thousands of tons. The westernmost surface exposure (the last outcrop on the plateau side) forms a prominent flat outcrop, a little distance from the southern edge of the plateau adjoining Kanakeri Waday deposit. This outcrop, unlike the others on the Yerin Dari, does not show a banded appearance and consists of three or four slightly detached flat exposures rising only a few inches above the surrounding ground.

The whole exposure of manganese-ore covers a superficial area of 2,622 sq. ft. Slightly below the edge of the plateau and at a distance of 100 feet from this outcrop, the bed is again exposed, and here the height is 8 feet. This exposure forms a prominent feature, the outcrop being extensive. The bed has been split up into numerous blocks by the joint planes. The ore, which is composed of psilomelane and pyrolusite, is brittle. This end, which covers a superficial area of 6,880 sq. ft., and strikes in a northerly direction, has apparently been disturbed. Towards the west, the bed disappears, and can only be traced by large boulders along the edge and on the slope.

(61) Yerin Dari Breccia formation.

Further west, at a distance of 260 feet from the above outcrop, there are numerous boulders of brecciated ore on the top of the plateau. This breccia consists mainly of a yellow schist in which numerous angular fragments of a low grade manganese-ore are cemented. There has also been a strong impregnation of the schist by infiltration of manganiferous solutions and joints along fissures so that the schist has been replaced by manganese minerals to a considerable extent; the chief mineral formed is wad. The crumpling up of the schist has produced numerous fissures, which have served as channels for the mineralising solution; this has filled up innumerable minute cavities with psilomelane and extremely delicate tiny acicular crystals, probably of manganite, so fine and so thickly grown that they present a black velvety appearance. Some of the cavities encrusted with psilomelane and lined with velvety crystals contain a white crystalline mineral which is carbonate of lime. These brecciated boulders give place a little further west to a conglomerate and then to pisolitic and oolitic manganese-ore cemented by ferruginous clay. At places, the cementing material is crusted with lime and also with silicate of alumina. The oolitic grains consist of compact psilomelane of concentric structure. This oolitic ore is succeeded by boulders of pisolitic and oolitic red hematite cemented by manganiferous and ochreous clay Further west, these are overlapped by a massive bed of pisolitic and conglomeratic hematite of complex character in which brecciated fragments of psilomelane are frequent.

(68) Jogonna Aditha Kolla deposits.

The manganese-ore beds, which flank the northern side of the Yerin Dari spur, overlook an immense cliff of manganese-ore, which is situated on the western side of the uppermost portion of Joganna Aditha Kolla. This precipitous manganese ore cliff, which derives its name from the ravine, is 90 feet in height as determined by aneroid readings. Measured along the base, the cliff bed is 550 feet in length. The maximum thickness across the strike on the top is 133 feet. The bed strikes in a N.-N.-W. direction and ends abruptly towards its S.-S-.E. extension having been cut off by erosive action. On the top of the main cliff there is another small cliff 10 feet high which gives place to another step-like succession of outcrop of ore. This is overlapped by a superficial deposit of iron and manganese-ores of secondary origin. Towards the north the outcrop of the principal manganese-ore bed is superseded by a patch of pisolitic hematite, limonite and also manganese in small proportion. This layer, consisting of pisolites, is encrusted with numerous fragments of steel grey hematite. Associated with this capping are massive blocks of oolitic manganese-ore cemented by a clayey medium. The spheroids vary in size from the size of a mustard seed to that of a pea. The cementing material is sometimes earthy hematite or limonite. The cracks, which are frequent, are filled with hematitic infiltrations. The oolitic ore, higher up on the plateau, merges into the common lateritic iron caps, which are composed of oolitic and pisolitic granules of soft red hematite cemented by compact limonite with vitreous lustre. The vermiculate tubules are filled with yellow and reddish ochreous minerals, and the infilling material, where it is not entirely decomposed exists as aggregations of minute microscopic oolites of earthy red and purple iron ore. Minute grains of quartz are also visible filling cavities. The oolitic and pisolitic iron-ore cappings, where subjected to denuding influences, have assumed the lateritic appearance and encrust the oolitic manganese-ore wherever depressions occur. The ferruginous infiltrations have filled up the fissures between joint planes.

The ore of the Joganna Aditha Ravine deposit shows wide ranges of variation from rich manganese oxide to wad of very inferior quality. The top and middle portions of the cliff contain an immense quantity of fairly good ore, chiefly consisting of psilomelane. The ore shows a highly schistose structure. In the lower part of the cliff, signs of decomposition, due to weathering, are conspicuous. A number of inclusions of argillite is also prominent. This argillite shows marked indications of alteration, and at several places kaolinisation has taken place. Yellow ochreous encrustations are also frequently found on the cliff. Stalactites and concretions of manganese-ore also occur in fair abundance. At the apex of the ravine, the cliff of manganese-ore gives place to argillaceous schist, which shows extreme weathering action. This schist is slightly manganiferous at places. Striæ and slickensides indicate that rock movement had once taken place here. The lower bed also shows signs of disturbance and of apparent unconformity.

(68) Character of the ore.

In the water-course at the apex of the ravine, a band of manganese-ore has been exposed by the erosion of the overlying laterite capping. The bed which is 100 feet in length and 44 feet in thickness strikes in a N-N-.W direction. The maximum exposed height of the outcrop is only ten feet. Towards the east the deposit is intercepted by a highly ferruginous schist which contains inclusions of silica in cavities. The ore is hard and consists of psilomelane.

(64) Joganna Aditha Kolla Karuvu deposits.

Booman Gadday Banda is situated one furlong due east of Chintamon Banda. This deposit presents a curious appearance, so much so that at first sight it may be mistaken for an outcrop of iron-ore stained by manganese.

(65) Booman Gadday Banda and Kattaydar Byalu outcrop.

The ore, however, is very rich in its manganese content, which is probably due to the abundance of pyrolusite pesudomorphous after manganite. The blue colour of the ore is marked. The deposit occupies a superficial area of 2,500 square feet. The strike is obscure. This is probably a portion of an extensive deposit which remains covered by detritus. The small manganese ore-outcrop on Kattedar Byalu, visible through the decomposition product of a highly ferruginous schist, probably marks its continuation south-eastward.

(66) Donay Banda.

About two furlongs due east of the northernmost outcrop of Chintamon Banda, there is a prominent outcrop of ore locally known as "Donay Banda" (water-hole rock) as there is a triangular hole in the manganese ore-bed in which water collects during the rains. This flat outcrop, which is exposed for a length of 189 feet, shows distinctly its bedded character. It strikes in a N.-W. direction. The ore is laminated and consists of psilomelane with occasional admixture of braunite. Towards the north, where the bed disappears under red loam, there is an infiltration vein of pisolitic limonite (altered at places into red hematite) cemented by impure manganese oxide and ochreous clay which contains grains of quartz. This vein is 24 feet long and two to six inches thick. Save for a few scattered ferruginous infiltrations, this deposit forms a rich ore-body.

(67) Onnay Marad Gadday outcrops.

Four detached outcrops are visible on the top of the plateau in a piece of flat ground, known as Onnay Marad Gadday, which is situated about three furlongs west of Alada Marad Banda and close to the Tonashigiri footpath. These outcrops are of the same mineralogic character, the ore bearing a striking resemblance to that of Badapatti Banda deposits. Minute crystals of braunite are conspicuous. The northernmost outcrop shows a length of 84 feet with a thickness of 31 feet. The bedding is obscured. The outcrop has been split up into numerous blocks by tension joints. A capping of gritty red soil covers this deposit on all sides. To the south there is a small dome-shaped outcrop which strikes in a N.-W. direction. Towards the south-east, this band, which runs for a length of 30 feet, is abruptly cut off by a band of highly siliceous hematite having probably the same strike.

(68) Durgamma Kolla deposits.

Durgamma Kolla—the most important manganese ore-bearing locality in the Sandur State—is a large ravine shaped somewhat like a horse-shoe. It is situated 1¼ mile south-east of Kammat Haruvu village. Manganese ore-deposits of great extent flank the upper portion of this ravine so conspicuously that the spectator is confronted with immense exposures of ore on all sides. Nowhere in the Sandur Ranges are so many large deposits found so closely grouped. The quantity of ore exposed in sight is simply bewildering and cannot fail to impress even the casual observer. On the top and edge of the plateau, beginning from the extreme end of the western arm of the ravine, with a few intervals, a series of manganese-ore deposits is traceable in succession for a length of nearly one mile up to the end of Karadi Badsala Kativi. These deposits present a conspicuously banded character. Some of them attain great horizontal and vertical distribution. The persistency of the strike, *viz.*, 55° W. of N., is observed in nearly every band. The dip varies greatly. Layers of hematite, of limonite and of phyllite intervene between the manganese-ore bands. Towards the interior of the plateau, nearly all the deposits are abruptly terminated by lateritic crusts of residuary mantle. In the process of sculpturing of the ravine immense quantities of ore forming the southerly continuation of these deposits had been carried away. The remnants now fringe the ravine on all sides in cliff-like exposures.

(69) Durgamma Kolla Western deposit.

The westernmost deposit is situated on the east of the footpath to Tonashigiri, just where it leaves the top of the Joganna Aditha Kolla spur and descends on the slope. In its southernmost extension, the deposit has been broken up into huge tabular masses by tension joints. This band is traceable continuously for a length of 300 feet. The maximum height exposed is 25 feet measured along the face of the cliff. The width is 56 feet. At the foot of the cliff the slope is covered by numerous boulders of manganese ore. On the top, the deposit loses itself under a capping of somewhat decomposed pisolitic red hematite. The ore shows schistosity and contains lenticles of wad, the removal of which at places has produced cavities in the ore-bed. This is one of the least prominent among the Durgamma Kolla deposits, but there can be no doubt as to its productive capacity as much of the ore-body remains hidden.

(70) Neerkolla Kativi deposits.

A well-marked band of manganese-ore crops out near the apex of the ravine about three hundred yards north of the western deposit. This flat outcrop which rises only a few feet above the surrounding ground is situated on the edge of the plateau south of Alada Marada Banda. The ore consists chiefly of psilomelane with thin streaks of a bright silvery oxide of manganese—the identity of which has not been established. At the surface, the ore appears to be brittle as it breaks up into pieces. This is due to highly jointed structure. Ferruginous infiltrations are noticeable in joint planes. A few yards from this deposit on the north there is another manganese ore-band similar in character. This deposit is exposed for a length of 74 feet and shows a width of 11 feet.

(71) Ald Marad Banda.

The large flat outcrop of manganese-ore on the edge of the plateau at the apex of Durgamma Kolla, known as Ald Marad Banda, is exposed for a maximum length of 600 feet with a width of 179 feet. Towards the east the banded character of the ore-body is marked, and on this side it rises to a height of ten feet. The deposit presents a curious appearance owing to the ore-body being split up into polygonal blocks. The ore is traversed at places by stringers of pisolitic limonite. Ferruginous infiltrations have penetrated through nearly every fissure in the ore-body, the value of which has consequently been depreciated. Towards the north-west, the deposit is masked by laterite. Alternation with bands of limonite is also seen on the edge of the plateau.

(72) Durgamma Kolla Banda.

Further east, the striking outcrop of Durgamma Kolla Banda runs parallel to the Ald Marad Banda. This band strikes in a N.-N.-W. direction and dips at a high angle. The N.-N.-E. exposure of the ore-bed is continuous for 460 feet. The maximum width of the outcrop is 112 feet. Towards the N.-N.-W. the deposit merges into a ferruginous phyllite which, as revealed by recent prospecting work, at places contains minor deposits of manganese ore of secondary origin. Towards the E.-N.-E., about three hundred and fifty feet from the N.-N.-W. extremity of this deposit, a band of hematite runs parallel to the manganese ore-bed. This band is traceable for a length of 34 feet. Then it disappears under residuary mantle, towards its S.-E. extension. It is again exposed in the bed of the small stream which during the rains crosses the Kenchamon Dona outcrop and falls over Karadi Badsala cliff. The ore of the Durgamma Kolla Banda is of high quality. It chiefly consists of psilomelane of a bluish colour containing at places much pyrolusite and geodes filled with manganite pseudomorphs. Braunite is absent. The ore at places is crusted with lime.

(73) Karadi Badsala Kativi.

Immediately behind the outcrop of the Durgamma Kolla Banda a band of manganese-ore is exposed as a cliff which surmounts the eastern arm of the Durgamma ravine. This cliff-forming manganese ore-bed is locally known as Karadi Badsala Kativi and extends over a length of 271 feet. As is characteristic of nearly all the principal Sandur deposits, the ore-bed has been split up into rectangular blocks by tension joints at right angles to the strike. The cliff represents only a portion of the original deposit which was either the continuation of the Durgamma Kolla Banda or a band parallel to it. It is apparent that a considerable portion of the original bed has been dislocated, as the foot of the cliff is covered by blocks of immense proportion consisting of ore identical with that of the cliff bed. It is difficult to convey an adequate idea of the appearance presented by the cliff of manganese-ore and the dislocated columnar masses of ore, such is the enormous quantity of manganese-ore visible in this part of Durgamma Kolla. The most prominent portion of the cliff bed is 21 feet high. Its downward extension is problematical. At this place it is exposed for a maximum width of 34 feet, the average width of the remaining portion of the cliff being about ten feet. The face of the cliff is coated by a thin chocolate coloured film at places highly stained by bluish and jet black manganiferous percolations. The lower part of the cliff has been subjected to considerable weathering action and several small cavities occupy the ore-body. The ore is extremely hard and consists essentially of compact psilomelane. Crystals of pyrolusite are frequently present and minute shining facets of braunite are sometimes seen. The Karadi Badsala Kativi cliff-bed contains a large amount of high-grade ore which is characteristic of nearly all the deposits in the Durgamma Kolla.

(74) The Durgamma Kolla great cliff bed.

The eastern arm of the ravine shows a step-like succession of cliffs of manganese-ore of which Karadi Badsala Kativi occupies the top-most position. The second cliff is situated a few feet from the foot of the Karadi Badsala Kativi cliff. This is one of the Durgamma Kolla ore-beds which is exposed in a cliff which attains a height of 47 feet. Measured along the base the cliff-bed is 186 feet long, throughout which the ore maintains its quality. Towards its north-westerly extension the manganese ore-bed is overlapped by a band of iron-ore which continues for a length of 80 feet. Behind this the manganese bands are again visible for 70 feet measured across the slope of the hill where they finally culminate in the Karadi Badsala cliff exposure immediately on the edge of the plateaux. The band of manganese-ore which forms the face of the main cliff of Durgamma Kolla is only a few feet thick, being intercepted by a band of limonite which alternates with it. Another band of manganese-ore runs parallel to this limonite band and continues up to the foot of Karadi Badsala cliff. This is the remnant of the uppermost cliff. The ore of the main cliff of Durgamma Kolla chiefly consists of psilomelane which is frequently mixed with pyrolusite. The face of the great cliff which forms an imposing sight is coated with ferruginous and manganiferous percolations which lend a deceptive appearance to the ore. Angular fragments of manganese-ore are found cemented to the face of the cliff. It is possible that these fragments once filled the fissure which originally existed in the ore-body and along which the bed has been fractured and dislocated, giving rise to the cliff exposure. The remnants of the dislocated portion of the bed are found strewn all over the slope and along the waterway in huge boulders which alone will yield several thousand tons of rich ore. On the north-east the cliff-bed is bounded by a conformable layer of phyllite which at places is highly decomposed and shows variegated colours. Further downward this red schist is exposed by the side of the Durgamma Kolla spring and it contains occasional encrustations and also stringers of manganese filling minute fissures and parting planes.

(75) Durgamma Kolla lowest cliff exposure.

The lowest cliff-bed of Durgamma Kolla is situated below the great cliff-bed. It is 24 feet in height and 53 feet in length. The maximum exposure of the breadth is 32 feet. The ore-bed is broken up into tabular masses by tension joints. Bands of limonite and highly ferruginous phyllite alternate with this bed. This is the outermost or the lowest of the manganese ore-bands which occupy the eastern arm of Durgamma Kolla in step-like succession. The foot of this deposit, where it disappears under the soil, is 100 feet below the top of Karadi Badsala cliff-bed which is overlaid by a band of highly ferruginous phyllite succeeded by the Kenchamon Doni manganese bands which occupy the highest position in the series.

(76) Kanchaman Doni bands.

Three detached outcrops form the Kenchamon Doni group of deposits. The north-east outcrop shows strongest development, being composed of two massive bands lying against each other. It rises 4 feet above the ground and has a length of 65 feet. The thickness is 37 feet. The S.E. outcrop is traceable continuously for 250 feet. It is abruptly terminated by hematitic schist towards its north-westerly extension. The band further north-west is probably the continuation of the south-eastern outcrop. This band is 300 feet long, 48 feet wide and 7 feet above the surrounding ground. Tension joints traverse all the band. The ore shows marked degree of schistosity and it is characterised by high quality.

(77) Karadi Badsala Kativi oolitic deposit.

Towards its south-eastern extension, the cliff-bed is intercepted by a band of hematite. Higher on the edge of the plateau another band is exposed for a length of 500 feet. This is probably the continuation of Ald Marad Banda. It strikes in a N.W. direction. The exposure of manganese ore on the top of Karadi Badsala spur is continuously traceable for a length of 1900 feet. The quantity of ore available from this area alone will amount to not less than a million tons. In the extreme south-eastern portion, there is an interesting deposit of oolitic manganese which forms a capping. It has a superficial area of 1800 square feet. This is the largest oolitic manganiferous deposit found in the Sandur State. The oolitic grains are composed of compact psilomelane. They are mostly of the size of a mustard seed. The spherules are closely packed together and cemented by brownish ferruginous clay. The grains show concentric coats. The deposit is irregularly fractured. Inclusions of lime are frequent in the oolitic masses. The deposit is 3 feet high. Lower down where the slope begins, the oolitic manganese is succeeded by boulders of a ferruginous conglomerate containing numerous rounded and angular fragments of hematite cemented by clay. Some of the fragments show a tendency to alter into limonite. In an advanced stage of decomposition, yellow ochre has also been produced. The oolites of manganese have apparently been deposited on the conglomeratic hematite bed.

(78) Other deposits on the Kammat Haruvu extension.

In the interior of the plateau which surmounts Karadi Badsala spur, there are two small outcrops of manganese-ore on a slight elevation known as Chitra Devar Gudda. Further south, on top of the ravine known as Jaldi Kolla, an extensive deposit is indicated by a series of manganese-ore blocks which have resulted from the splitting of the outcrop which has been subjected to considerable denudation. The ore bed crops out prominently towards the south-east in the shape of bands projecting on the slope just below the summit of the spur. This deposit extends over a length of 638 feet. Not far from this are situated the deposit known as Yerra Guddina Kare Kallu and Mala Kolla Banda. The outcrop of the former shows ore of a concretionary type on the surface which makes its primary origin doubtful. The Mala Kolla deposit strikes in W.-N.-W. direction and has got a continuous exposure of 800 feet. The ore-bed dips at about 45°. Towards the E.-N.-E., the bed ends abruptly, having been entirely removed by denudation which has resulted in the formation of a saddle between Mala Kolla Bandy and Janal Haru. A gritty schist, which forms the boundary of the ore-bed on the N.-E., is exposed on this saddle. The bed is intercalated by a dense highly ferruginous schist containing abundant specks of mica. The contact between the alternating layers forms a sharp boundary. The ore of this deposit contains much pyrolusite which preponderates in some parts. The other manganese-ore occurrences further east on Janal Haru and other spurs have no economic importance at present.

2.—HANUMANTHANA HARUVU GROUP.

(79) Hanumanthana Haruvu Doni Banda.

To the west of Kammat Haruvu lie two plateaus which have almost the same elevation as itself. These plateaus, namely, Hanumanthana Haruvu and Manal Haruvu, which are connected with each other and which probably formed a continuous table-land of wide extent, are now separated by a system of great ravines and valleys. The top of the small spur, forming the western arm of Hunasimarad Kolla (which divides Kammat Haruvu and Hanumanthana Haruvu), contains a bold elevated narrow band of manganese-ore, which strikes in a north-east direction. This outcrop is known on account of a small waterhole as Hanumanthana Kativi Donay Bandi. The ore-bed is traceable for a length of 250 feet along the strike. Where the bed at its south-western extremity disappears under the soil the exposed breadth of the outcrop is only 6 feet as it is obscured by the soil capping. At this end, the ore shows considerable impoverishment, being soft and poor in its manganese contents. This bed is distinctly stratified throughout its extension. The maximum breadth is 26 feet and the height exposed above the surface of the plateau is only 4 feet. The top of this outcrop has been subjected to considerable weathering action. The ore in the lower portion is richer and more compact and consists of psilomelane with crystals of braunite interspersed in fair proportion. At places grains of quartz are found in abundance imbedded in a cellular structure, which gives a spongy appearance to the ore. The ore in the upper part is frequently ferruginous and sometimes the cavities are filled with limonite. This deposit is about half a mile from Hunasimarad Kolla spring. There is a large number of boulders of manganese-ore on the southern slope of Hanumanthana Kativi not far below the edge of the plateau, which probably indicates the extension of the ore-bed; such extension, however, cannot be traced on this slope.

(80) Hanumanthana Kativi and Pathargani Muli.

The spur known as Pathargani Muli, which projects in a south-easterly direction, is situated on the south-west of Hanumanthana Kativi. There is a small end-exposure of a bed of manganese ore on the north-eastern edge of the top of this spur which branches out of the plateau. Measured across the strike it is 75 feet in width. The maximum length exposed is 20 feet. Owing to extreme weathering the strike of the outcrop is not visible. But the bed apparently runs in a north-east direction, the general trend of the deposits on this plateau. The ore on the surface presents a honeycombed structure. This is due to the removal of the clayey constituents of the ore. Towards the north-west a bed of hematite is exposed and it runs parallel to this manganese band. On this side the ore is highly ferruginous and merges into hematite. Away from the hematite bed the ore becomes richer in manganese and frequently contains an abundance of pyrolusite. At a depth of 13 feet (maximum height), where the bed disappears under the soil capping, the ore shows considerable improvement in quality, with preponderance of psilomelane. Towards the south-west a band of hematite intervenes, probably between another band of manganese-ore, which is completely obscured but is indicated by an abundance of boulders distributed on the surface. Towards the south at a short distance from this hematite band, which presents a brecciated appearance, there is an exposure of manganese-ore (6 feet in height) 50 feet in extent, and from the foot of this exposure the slope begins. At this end the plateau rises considerably in elevation, forming a horse-shoe shaped prominence with a flat top, which has survived the general denudation apparent in this area. On this prominence the remnants of the original manganese ore-bed are visible in the shape of a group of boulders of massive proportions, showing considerable signs of weathering. The ore is soft and at places schistose. It is more than probable that these boulders are now covering up part of the original bed which survived denudation; prospecting will decide the question of its existence.

(81) Hanumanthana Haruvu deposits.

The surface of Hanumanthana Haruvu shows the underlying laterite formation, wherever it has been exposed by the denudation of the soil. On the south-eastern edge of the plateau several huge blocks and boulders of manganese-ore of a mixed character form conspicuous objects. These boulders which weigh several tons each must have formed part of an original bed. However, the ore being low in manganese and sometimes admixed with hematite is of little economic value. Prospecting will lead to the finding of the bed (which is likely to contain superior ore) from which the boulders have been derived. There are four more similar exposures on the western edge of Hanumanthana Haruvu near the footpath to Swamihalli.

(82) Basiri Maridi Kativi.

The deposit known as Basiri Maridi Kativi is interesting as it is situated on the slope of the hill, about three hundred feet below Mannal Haruvu. This difference of level in the position of the deposits is noteworthy. The deposit crops out just outside the southern boundary of the Sandur State and within the Tonashigiri Forest Reserve of Kudligi Taluk, and takes the form of two low cliffs which run almost in a line and which have been separated by denuding agencies. These cliffs are situated on the lower portion of the spur known as Basirimarad Yenu, which forms the western arm of Girenath Kolia. The deposit strikes in a north-east direction and dips at a high angle. The face of the cliffs is stained by manganiferous percolations and is coated by red rust which renders the deposit liable to be mistaken as a ferruginous ore-body. The first cliff runs continuously for about 150 feet towards the north-west where it ends abruptly, being obscured by detrital remains. It again reappears after a short interval and runs for nearly 200 feet. At several points the exposed height of the cliff is 10 feet. The visible width is small as the top of the deposit is covered by residuary mantle. The ore appears to be of inferior quality but at places is rich in its manganese contents. It is compact and hard and contains abundance of pyrolusite and altered manganite. The foot of this bed is covered with small boulders, and nodules are met with, some of which consist of manganese ore which has replaced quartzite. This ore contains much braunite and free silica. Sometimes the replacement has not been complete and decomposed quartz is present as core in the centre of the boulders.

3.—Mannal Haruvu Group.

(83) Tambal Naikan Paddi, Gadigal Tattu, etc.

The plateau known as Mannal Haruvu is separated from Hanumanthana Haruvu by a deep ravine known as Ram Kolla. The superficial area of this plateau is small. Nevertheless, it contains a number of important deposits. The outcrop known as Budhana Gundu consists of a huge boulder-like projection of manganese ore, some seventy-five feet high. Numerous boulders cover the slope of the hill at the foot of this deposit where an exposure of phyllite is also observed. The deposit designated after Tambala Naikan—a chief of some importance in former times—although obscured by a bed of hematite, shows a large quantity of good psilomelane. The cave in which the old chief took refuge has been formed within a mass of manganese-ore. The most important of the deposits on this plateau are those at Gadigal Tattu and Girenath Kolla. The Gadigal Tattu manganese ore-band which strikes in a W.-N.-W. direction is 300 feet long and 100 feet in width. It forms a low cliff-like exposure 18 feet high. The ore appears to be of high quality. The main deposit at Girenath Kolla is situated on the northern flank of the ravine. The ore-bed forms a cliff 150 feet long and 27 feet high. It strikes in E.-N.-E. direction and dips at 45 W. of N. The strata show a highly schistose formation like that at Jogannaditha Kolla. The ore-bed has been weathered to a marked degree. At the W.-S.-W. end the ore has lost its schistosity and is composed of hard psilomelane of extreme compactness. The latter contains veins of pyrolusite, and shining facets of braunite crystals are frequent. At this end there is a small cave in the ore-body which contains layers of hematite showing crustification.

4.—KUMARASWAMI GROUP.

(84) Tappal Paddi, Hulisatta Banda, etc.

Nearly all the deposits in the Kumaraswamy valley and the adjoining portion of the plateau are of large extent. A series of extensive deposits located on Tappal Paddi (" Tobacco field '')[1] faces the ancient temple of Kumaraswamy on the south-west. One of the "Tappal Paddi" deposits which forms a cliff about 20 feet high is called "Hooli Satta Banda."[2] The ore of this outcrop is extremely hard and compact and contains a bright crystalline manganese mineral which has not yet been identified. There are also patches of finely oolitic manganese and iron ores encrusting some of the manganese outcrops and sometimes filling cavities in the ore-bed. The "Tappal Paddi" area contains more than one manganese ore-band traceable over several hundred yards. The bands crop out on the top as well as on the edge of the plateau. To the south of the Temple the "Badial Marad Kativi" deposit shows three immense boulder-like outcrops of manganese-ore which is also exposed in cliffs further southward. Two extensive manganese-ore bands known as Errakan Muli deposits run parallel to the "Badial Marad Kativi" deposit. Further south large outcrops stretching far and wide are exposed on the Bandijadi Kativi portion of the Yello-Suttina Plateau. The quantity of high grade ore available from the Bandijadi Kativi and Sillu Kolla deposits can be estimated at hundreds of thousand of tons.

5.—SUBRAYANHALLI AND TUMBARAGUDDI FOREST GROUP.

(85) Kanegina Marad Kolla, Chennangi Marad Kolla, Hallay Marad Dono, etc.

With the exception of the Tappal Paddi deposit which has been included in the description of the Kumaraswami group of deposits, the manganese-ore deposits on the plateau of Subrayanhalli appear

[1] This area is so named as years ago tobacco plants were grown here.

[2] Some years back, a dead tiger was found on the top of this manganese cliff which since has come to be designated as Hooli Satta Banda or "dead tiger rock."

to be of minor importance as the outcrops are very much obscured by ferruginous cappings. The deposits at Nawalswami Kolla Kapatswami Kolla, Kanegina Marad Kolla and Chennangi Marad Kolla although extensive are comparatively inaccessible. In these localities the ore is highly ferruginous. The low level deposits at Subrayanhalli Neer Kolla and in the immediate vicinity of Chennangi Marad Kolla are interesting, as these large deposits are situated several hundred feet below the plateau deposits. A large cliff-like exposure of manganese-ore is situated half-way on the slope of the Neer Kolla. Another flat exposure of ore 1663 feet long is seen at a short distance and at a much lower level forming the top of a low spur which projects from the main range. In the appearance of the cliff-bed there is nothing which suggests a different mode of origin from the main deposits on the top of the Sandur Hills. But the ore of the flat outcrop, although it preserves its schistosity, the strike and dip of the deposit are obscure. The ore at places shows brecciated and concretionary structure. Lenticular patches of hematite and limonite are also present. The ore rapidly gives place to phyllite in the downward extension. Although this deposit is apparently of secondary origin, the author is inclined to place it in the category of contemporaneous deposits. This remark applies also to the other low level deposits at Hallay Marad Doni, Basiri Marad Kativi, Agasar Tattu, etc. It is suggested that these represent deposits which were originally laid down on the floor of the sea at a short distance from the main manganese ore-deposits which now crop out on the top of the hills. Erosion has laid them bare on the lower slopes of hills, wherever it has reached a sufficient depth to uncover the deposits. The upper portion of the low level deposits have also been removed by denuding agencies, and hence the deposits are limited in their downward extension. Such deposits have probably been derived from a neighbouring deposit of manganese ore as there is evidence to show that, owing to repeated de-oxidation and re-oxidation, the transfer of manganese minerals from one position to another on the floor of the sea takes place [1]

6.—Kanevihalli Range Deposits.

(86) Achcha Kolla, Mottu Kolla, Hatti Penta, etc., deposits.

The most important of the deposits on the hills comprising the Kanevihalli Range are all situated within one and a half mile south of the great Oblagandi Gorge. They include the extensive ore-beds on Mottukolla Haruvu, Achcha Kolla, Ganigithi Kolla, Alada Marada Haruvu, Mudiki Thaggu, Budhana Gundu and Hatti Penta. At least three parallel ore-bands can be traced on Mottukolla Haruvu at intervals of a few hundred feet. These are the deposits known as Mottu Kolla Kativi, Mottu Kolla plateau deposit, and Achcha Kolla Kativi. The first is characterised by rich blocks of manganese ore, at times highly ferruginous, which forms an extensive bed split up by numerous joint planes. The south-easterly extension of this deposit has been eroded away during the formation of the valley which now bifurcates the plateau into two parts, above Ganigithi Kolla. This manganese ore-deposit grades downward into the underlying highly ferruginous phyllite. A gritty ferruginous schist forms the boundary of the deposit on the west. The deposit on the top of the plateau does not show a bold outcrop. The

[1] John Murray, LL.D., Ph.D., and Robert Irvine, F.C.S., On the Manganese Oxides, and Manganese Nodules in Marine Deposits, in the Transactions of the Royal Society of Edinburgh, Vol. xxxvii. part iv, p. 739.

ore is a bright bluish psilomelane with an admixture of finely crystalline braunite. This deposit appears to contain a large amount of high grade ore. It is surrounded on all sides by a ferruginous mantle. A short distance east of this outcrop, the deposit which crowns the top of Achcha Kolla shows itself most prominently as a long cliff of manganese-ore which skirts the edge of the plateau. This ore-bed is traceable for a length of about seven hundred feet. The ore at places contains much pyrolusite which is responsible for its brittleness Psilomelane of a rich quality constitutes the main mass of this ore-body. This is one of the most extensive deposits on the Kanevihalli Range. The plateau on the top of Ganigithi Kolla, a little south of Mottu Kolla, also shows three parallel deposits of large extent. The westernmost deposit forms a low cliff-like exposure, which is traceable over several hundred feet along the edge of the plateau. It is associated with the same rock-formations which are exposed in the vicinity of the Mottu Kolla Kativi deposits. It is probable that these deposits were connected with each other before the carving out of the valley which now separates them. An immense columnar outcrop of manganese-ore known as Budhana Gundu on the south-east marks the position of another deposit of manganese-ore which probably extends towards the plateau but is marked by a lateritic formation. The Budhana Gundu outcrop is about seventy feet high and is a most imposing object in the landscape. The ore-body contains a number of hollows and caverns which have been formed by the removal of lenticles of argillaceous schist. The junction of the phyllite with the ore is visible at the foot of the deposit, which passes abruptly into the schist. A little below, there are massive exposures of a yellow argillaceous schist in an advanced stage of decomposition. This schist contains inclusions of wad filling minute fissures and cavities. At places, the parting planes have been filled up with manganiferous minerals giving rise to a banded structure in contradistinction to the mottled appearance which is more conspicuous. A little further on the top of the plateau a large band of good manganese-ore locally known as Ald Marada Bandi crops out. The Mudigi Thaggu deposit is also situated close by. About half a mile south-east of this, one of the most important deposits on the western range is uncovered at Hatti Penta, which is probably the continuation of the Mottu Kolla and Ganigithi Kolla deposits. The same rock-associations prevail here. The deposit forms a long cliff which fringes the western edge of the plateau. Immense quantities of rich ore are exposed as forming the deposit. Dislocated boulders cover the slopes, and from this source alone several thousand tons of ore may be raised. The ore-body has been split up into numerous rectangular blocks by tension joints. The ore is a rich psilomelane containing pyrolusite and braunite as admixture. Inclusions of a carbonate of lime have also been observed. There are some more deposits on the south of the Kanevihalli Range. But these are not so important as those noticed above. Among the numerous boulder beds which are found at the foot of the Kanevihalli Range nearly every deposit on the edge of the plateaus, those at Mottu Kolla, Ganigithi Kolla and Ald Marad Kolla deserve mention as several thousand tons of ore have been shipped from these immense talus ore-accumulations.

7.—Ramandrug Range Deposits.

The gorge of the Narihalla river, known as Obla Gandi, separates the Kanevihalli Range from the Ramandrug Range. As once the hills comprising these ranges were continous before the Narihalla effected her passage through the great barrier, it is not unnatural that the deposits on the Ramandrug Range occupy positions which correspond with the mode of occurrence of the deposits on the Kanevihalli Range. The western side of the Ramandrug Range shows a succession of ravines carved out at almost regular intervals giving rise to somewhat symmetrical arrangement of spurs and ravines. Manganese-ore bands of great extent are traceable from spur to spur, their continuity being only broken by the intervening ravines. It is useless to speculate on the quantity of ore carried away by erosive processes during the carving out of the valleys and ravines. As on the Kanevihalli Range, deposits on the Ramandrug Range occur at three distinct ore-horizons. Such occurrence is well seen on the plateau of Ramandrug Hill.[1] Just north of the Oblagandi there are important deposits on Seshgiri Haru, Kadlekan Haru, Mat Kolla, Baray Marad Dinnay, in fact all the plateaus up to Sanna Sil Haru north of Ramandrug contain more or less extensive deposits, the number of unimportant deposits being limited. The deposit at Gaddel Tattu and the two parallel bands of ore on Seshgiri Haruvu are interesting as they show alternation with ferruginous phyllite and specially as they are situated close to exposures of basic rocks which underlie them. Northwards beyond Seshgiri, laterite attains great development on all the plateaus and often masks manganese-ore beds which are probably of great extent. An erroneous impression prevails that the

(87) Seshgiri, Kadlekan Haru, Mat Kolla, etc., deposits.

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[1] The Ramandrug deposits will be fully described in Mr. Fermor's forthcoming memoir on the manganese-ore deposits of India.

largest deposits in the Sandur State are situated on the Ramandrug Hill. But the deposits on the Ramandrug plateau, although extensive and favourably compare with some of the largest manganese ore-deposits in other parts of India and elsewhere, yet cannot bear comparison with the deposits on the other ranges. In spite of its comparative unimportance as to productive capacity and quality of ore, the author was obliged to start mining work first on the Ramandrug main bed as it was the only deposit in the State which was situated close to a road leading to the Mariamanhalli station on the Southern Mahratta Railway. The main bed at Ramandrug has already been briefly described. A series of parallel bands traceable by their projection on the topmost part of the Mavin Marad Kolla shows large ore-bodies between which layers of limonite and phyllite intervene. These deposits are known as 'cave deposits,' as there are some large caves in the ore-bodies. Some of these deposits contain large veins of limonite and hematite. Further east a band of manganese-ore crops out just below the edge of the plateau near the road to Hospet. The ore of this band is characterised by an excess of braunite in minute crystals. One of the most important of the manganese ore-beds is situated in the south of the plateau, close to the bastions of the old fort. This deposit is known as the "Fort wall" as remnants of a line of defence built of blocks of laterite still surmount it. This is perhaps the richest ore-body in the Ramandrug portion of the range. It forms a low cliff-like exposure which attains the minimum height of 26 feet. Below the manganese-ore rapidly gives place to a conformable layer of hematite. The ore chiefly consists of psilomelane, at places possessing extreme hardness. Minute facets of crystals of braunite are visible in the amorphous groundmass of psilomelane. On the south-east the ore-body is intercepted by a ferruginous outcrop. On the top of the plateau the deposit is traceable for a short distance by unobtrusive outcrops which give place to laterite. The deposits of manganese-ore near the cemetery and under the barracks are highly obscured by lateritic encrustations and residuary mantle. The plateau of Sanna Sil Haru on the north of Ramandrug contains at least two parallel bands of manganese ore. The outcrops are prominent on the top of the plateau as well as on the edge. The ore is frequently mixed with iron on the top and vugs of limonite and hematite occur in the ore-body. Bands of hematite alternate and run parallel to the manganese ore-deposits. Minor deposits occur on the spurs north of the Sanna Sil Haru. But with the possible exception of Kalhalli Gudda deposit, situated in British territory, no workable deposits are known in this part of the Ramandrug Range.

VI.—CHARACTER AND COMPOSITION OF ORE.

(88) Macroscopic character.

As is to be expected from the striking persistency of the stratified structure of the manganese ore-beds, the ore is characterised by a degree of schistosity which attains conspicuous development in most of the ore-beds. This slaty structure is sometimes further accentuated by extremely thin alternating films of chocolate colour, due to infiltrating solutions filling the parting planes between the layers of manganese ore. This kind of ore is more frequently met with in the Ramandrug Range deposits than elsewhere. The schistosity of the ore when combined with a dull lustre sometimes presents an appearance so similar to slate of a dark colour that the ore may be mistaken for a non-metalliferous schist with the cleavage highly developed. The individual layers of the laminated manganese-ore so characteristic of the Sandur deposits preserve their continuty in a remarkable manner. This continuity is broken by tension joints which traverse nearly all the deposits at regular intervals with uniformity of angular disposition. The preservation of schistosity is more frequently interrupted by minute fissures and cavities which at times give rise to highly cavernous and brecciated ore. These fissures are frequently found filled with veinlets of ore of secondary origin. The cavities which range in size from a fraction of an inch to several inches across almost invariably contain aggregations of brilliant acicular crystals of manganese minerals projecting towards the central druse. Concentric layers of manganese minerals of different density and crystalline habits line the geodes and form the base from which the needle-like prismatic crystals spring up. The ore in the main presents a decidedly bluish colour with a dull metallic lustre. Schistosity, amorphous structure, bluish tinge and dull lustre are the predominant features of the bulk of the Sandur manganese-ore. Brittleness is another characteristic present in the ore of some deposits. But several deposits contain an extremely hard ore, the winning of which is not easy of accomplishment.

(89) Mineralogical forms — psilomelane and wad.

The ore of the Sandur deposits essentially consists of oxides of manganese, carbonates and silicates being so far undetected. Psilomelane is the principal ore of the area predominating far in excess over other ores of manganese. Two varieties of psilomelane occur, the most widely distributed possessing medium density, bluish black colour and sub-metallic lustre. Psilomelane of a highly compact texture and lead grey colour is mainly found lining drusy cavities and sometimes in masses of considerable proportion. This psilomelane is an alteration product of the less compact variety which has been dissolved by heated waters and then redeposited under pressure in more compact form. Consequently it has a higher specific gravity. An impure oxide of manganese of low specific gravity and often porous in structure is sometimes associated with psilomelane. This black and brownish mineral of indefinite composition is probably a form of wad—at least it has been designated as such, as its exact mineral character is as vaguely understood as that of wad. It has been erroneously supposed that this mineral is a decomposition product of psilomelane or other manganese-ore. On the contrary, secondary enrichment of this so-called wad whenever it has taken place has converted it in part into purer oxide of manganese, with the loss of volume and original structure and increase in specific gravity. While in part this impure manganese mineral is the product of replacement of some constituents of the phyllite, it is more often the result of direct sedimentation and is contemporaneous in origin with psilomelane. The schistosity which is so characteristic of the Sandur deposits is well preserved in wad.

(90) Pyrolusite and manganite.

Next to psilomelane, pyrolusite is an important constituent of the Sandur manganese-ore. It occurs in great abundance in granular masses in some of the deposits on Kammat Haruvu. In this form it is also found sparingly distributed in several deposits on the Ramandrug and Kanevihalli Ranges. Radiated, finely crystalline aggregates of pyrolusite filling fissures and alternating with psilomelane occur in profusion in most of the Sandur deposits. It is probable that in many cases the pyrolusite is an alteration product and is pseudomorphous after manganite, another most characteristic mineral of the area. Acicular crystals of manganite[1] of great beauty and extreme fineness are invariably found lining cavities or infilling narrow fissures which are so common in the ore-bodies. Geodes filled with concentric radiated or brushlike fibrous aggregations of manganite show concentric deposition of compact psilomelane on the walls forming the base from which the crystals of manganite project towards the central druse. The elongated prismatic crystals vary in size. Sometimes they have been found about one inch long; more frequently they are less than half an inch in length. In a specimen Mr. Fermor found the needles to average $\frac{1}{2}$ inch in length with thicknesses ranging from 0·02 to 0·2 m.m., from which an idea of their delicacy may be formed. Under the microscope the needles show as elongated prisms with their prismatic faces deeply striated vertically. This striation is not visible in the extremely delicate crystals which occur as dark-green velvety tufts lining cavities. Such crystals rarely occur and have only been found at Ganigithi Kolla, whereas the coarser kinds occur nearly in every deposit in the Sandur area. The deposits on the Ramandrug plateau and at Danada Turumendi have yielded some of the finest specimens of manganite and pyrolusite. As has been remarked above, in many cases the crystals of manganite have undergone alteration and have changed into pyrolusite with loss of water.[2] Such

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1 L. Leigh Fermor, A.R.S.M., F.G.S.—" On Manganite from the Sandur Hills" in the Records of the Geological Survey of India, Vol. xxxiii, Part 3, pp. 229-232.

2 A. Ghose—" On the Mode of Occurrence of Manganite in the Manganese

pseudomorphs of manganite are common. But the alteration has not always been completed. Thus it has been fouud that some specimens contain a percentage of water which is much lower than that present in manganite. As Haidinger has remarked, this species of manganese mineral shows considerable variation in composition. The difference of hardness is a useful criterion in establishing identity of pyrolusite and manganite. The brownish streak of manganite also distinguishes it from pyrolusite. The best way of judging the colour of the streak is that indicated by Haidinger,[1] namely, by rubbing the crystal on a porcelain plate and then removing the black powder when the characteristic brown tint of manganite appears. Another means of ascertaining the identity is by heating the mineral when pyrolusite will yield oxygen, but not manganite. The writer by applying these simple tests to a large number of doubtful specimens of manganite has come to the conclusion that complete alteration into pyrolusite has not always taken place. Complete chemical analysis is the safest guide to identification. But for crystals which preserve the form of manganite but do not resemble either that mineral or pyrolusite in composition, the name 'pseudo-manganite' has been provisionally proposed by Dr. Fermor.

(91) Braunite.

The Sandur deposits are remarkable for the singular absence of braunite in any considerable quantity. In this respect most of the manganese-ore deposits in the Central Provinces supply a sharp contrast to the deposits under consideration.

Ore-Deposits of the Sandur State" in the Transactions of the Institution of Mining Engineers, Vol. xxxv, Part 5, pp. 685-691.

[1] W. Haidinger, F.R.S.E.—"Mineralogical Account of the Ores of Manganese" in the Transactions of the Royal Society of Edinburgh, Vol. xi, Part I, p. 127.

The absence of silica in the Sandur ore is partly governed by this rarity of the occurrence of braunite Braunite is almost entirely absent in those deposits of the Sandur State which lie immediately above the gritty ferruginous schists and occupy places in the lowest manganese ore-horizons. In the upper horizons, the proportion of braunite shows a marked increase and the ore is a mixture of small crystals of braunite with preponderance of psilomelane. Even then the percentage of braunite is almost negligible. The braunite of the Sandur deposits occurs in minute octahedrons which are slightly magnetic and are so distinguished from crystals of magnetite which possess magnetic property in a high degree. Its colour is dark black. With fluxes, it readily gives reaction for manganese. When dissolved in hydrochloric acid, a gelatinous precipitate collects in the test tube. These tests are sufficient to distinguish the crystals of braunite from those of magnetite.

(92) Other manganese minerals.

No hausmannite has yet been found in the Sandur State. However, there are two or three manganese minerals which occur in this area which deserve special examination. One of these is a bright silvery crystalline mineral which is frequently found in association with manganite. Another manganese mineral with high metallic lustre is sometimes found filling narrow fissures. This mineral is amorphous in structure. No attempt has yet been made to determine the exact character of these and a few other peculiar manganese minerals which occur. The discovery of several new mineral species comprising hollandite, vredenburgite and sitaparite, etc., by Dr. Fermor in the manganese-ore deposits in other parts of India ought to stimulate research as to the nature of some of the peculiar manganese minerals of the Sandur deposits.

(93) Mineral association.

Only a few minerals are found associated with the manganese-ores of the Sandur deposits. Of these limonite and hematite occur frequently filling fissures and cavities. Such ferruginous infiltrations are common in some of the Ramandrug Range deposits. They are rarely present or entirely absent in the deposits on the Kammat Haruvu. As these minerals are mostly of secondary origin being derived from the over-lying iron ore-beds, their presence in fissures and cavities is natural. The limonite frequently shows fibrous or mammillary structure. It is also found in the massive state. Specularite, magnetite, and mangan-magnetite have been noticed in several deposits. These minerals may have been deposited originally with the manganese-ore. Encrustations of calcium carbonate are sometimes found filling cavities. A specimen analysed by Mr. D. Hooper, Curator of the Industrial Section of the Indian Museum, was found to consist of pure calcium carbonate. Another white mineral occurs in thin films and rarely as stalactitic and lamellar masses. This amorphous mineral has been identified as allophane. It gelatinizes in hydrochloric acid with separation of silica. Thin films of allophane of bluish colour are frequently found in the Kala Badsala Kat vi deposit. Inclusions of silica occur rarely in the Sandur deposits. Minute grains of quartz are found imbedded in a cement of manganese which gives rise to characteristic cellular structure. It is surmised that fragments of quartz were imbedded in the original precipitate of manganese ore. In some cases the crypto-crystalline quartz has been enlarged into larger pellucid individuals.

(94) Commercial value and chemical composition.

The ore of the Sandur deposits is characterised by extremely low percentage of phosphorus and silica. It is singularly free from sulphur and other injurious elements. Absence of injurious ingredients, an almost negligible quantity of silica and phosphorus, and a sufficiently high percentage of manganese render the Sandur ores eminently suitable for the manufacture of spiegeleisen and ferro-manganese. The only constituent which slightly detracts from the merit of the Sandur ore is its rather high iron content. Shipment analyses have sometimes shown as much as 16 per cent. of iron. This excess of iron at the cost of manganese content depreciates the value of the ore to a certain extent. But the consumers of the Sandur ore have little cause for complaint as when they pay for the ore solely on the basis of manganese content, they get a certain quantity of iron without charge. In fact, the Sandur ore is appreciated for its iron content which is above the average. But the chief excellence of the ore lies in its invariably low percentage of silica and phosphorus and consequently the ore is immune from being penalised. The constancy of composition of the Sandur ore is frequently disturbed by ferruginous infiltrations which sometimes penetrate into the ore-bodies. The value of the ore varies in proportion to the effects of secondary enrichment and impoverishment. Where the ore which principally consists of psilomelane contains much pyrolusite and manganite the value of the ore is as a consequence enhanced. But the distribution of richer manganese minerals in the ore-bodies is rather erratic and consequently the composition of the ore varies to a great extent. Analysis of hand specimens cannot serve to represent the composition of the bulk of ore in any deposit. The variability of composition is solely due to secondary enrichment and degradation from ferruginous infiltrations. Otherwise, the ore-bodies would have shown remarkable constancy of composition within individual ore-horizons, having been formed under identical circumstances. The following analytical results will throw some light on the quality and composition of the ore of some of the deposits.

A. Analysis of Individual Specimens.

(1) Specimens from Ramandrug main bed :—

Extremely hard, bright, silvery ore essentially consisting of a crystalline manganese mineral which has not been identified :

Manganese	54·39
Iron	5·38
Silica	0·59
Phosphorus	0·01

(2) Specimen from the same locality :—

Rather soft psilomelane showing highly schistose structure, the principal ore of the Ramandrug Main Bed :

Manganese	46·11
Iron	12·30
Silica	·73
Phosphorus	·067

(3) Specimen from the N.-W. extension of Ramandrug Main Bed :—

Psilomelane with wad. Comparatively heavy ore :

Manganese	39·47
Iron	16·00
Silica	·67
Phosphorus	·02

(4) Specimen from the Main Bed :—

Compact psilomelane with streaks of pyrolusite :

Manganese	53·54
Iron	6·00
Silica	·50
Phosphorus	·03

(5) Karadi Badsala Kativi :—

Psilomelane with minute crystals of braunite :

Manganese	50·14
Iron	10·02
Phosphorus	·028
Silica	1·04

(6) Danada Turumendi :—

Soft ore chiefly consisting of pyrolusite :

Manganese	55·47
Iron	5·00
Phosphorus	·014
Silica	·46

B. ANALYSIS OF AVERAGE SAMPLES TAKEN FROM THE ORE-BED.

(1) Ramandrug 'Main Bed' (blue ore):—

Mn.	48·94
Fe.	10·39
SiO_2	·80
P.	·077

	Mn.	Fe.	SiO_2	P.
(2) Karadi Badsala Kativi—Western slope main deposit—	48·55	12·84	·90	·016
(3) ,, bedded outcrops and boulders. Ore sometimes coated with thin films of allophane—	45·49	12·54	1·25	traces.
(4) Galay Banda	44·16	16·66	1·05	·023
(5) Durgamma Kolla Banda ..	48·15	12·64	·75	·019

C. COMPLETE ANALYSIS OF AN AVERAGE SAMPLE FROM A CARGO-LOAD.

Peroxide of Manganese	62·28
Protoxide of Manganese	4·80
Peroxide of Iron	20·29
Alumina	3·46
Carried over .	90·83

Brought forward ..	90·83
Calcium Carbonate	0·60
Magnesia	*Nil*
Silica	1·00
Sulphur	0·027
Phosphorus	0·036
Copper, Lead, Zinc, Arsenic	*Nil*
Combined Water	6·96
Carbonic Acid	0·21
Total ..	99·663

Manganese (metal) .. 43·09%
Iron (,,) .. 14·20%

D. SHIPMENT ANALYSIS.

(*Ramandrug and Kanevihalli Ore*).

Date.	Steamers.	Tons.	Mn.	Fe.	Sio	P.	Moisture.
1907.							
March 4th ..	"Wellington" ..	820	44·16	..	0·89	0·04	0·35
March 31st ..	"Penlee" ..	1800	45·35	..	1·35	0·04	0·30
June 13th ..	"Larne" ..	1800	46·51	12·70	0·82	0·07	·051
July 23rd ..	"Blackmoor" ..	2650	44·95	12·80	0·80	0·04	1·64
Septr. 18th ..	"Clan Stewart" ..	2500	42·22	14·91	1·21	0·04	2·19
Octr. 18th ..	"Clan Ross" ..	1200	40·63	15·80	1·72	0·04	2·20
Novr. 29th ..	"City of Vienna" ..	3300	41·08	14·79	2·60	0·11	1·10
Decr. 2nd ..	"Clan Sinclair" ..	2000	40·21	16·30	1·93	0·03	1·10

All the ore so far shipped has been derived from the Main Bed at Ramandrug and from the talus ore-accumulations at the foot of Mottu Kolla, Ganigithi Kolla, Ald Marad Kolla and Gedel Tattu. The ores from these deposits comprise mainly the poorer grades, and it must not be concluded that they represent the quality of the ore generally found in the Sandur deposits. The deposits on the Kammat Haruvu and Kanevihalli Range contain an abundance of high grade ore which remains untouched owing to the great difficulties of transport.

VII.—ORE RESERVES.

(95) Estimation of the quantity of ore.

An attempt will here be made to give an idea of the quantity of ore available from a single group of the Sandur deposits. For this purpose, out of numerous equally extensive deposits, those on the Kammat Haruvu have been chosen, as these in several cases show good exposures of ore-bodies. The length and width of the outcrops are in a great number of cases exceptionally well defined. In some cases the downward extension of the deposits is easily measured so far as it is exposed. In estimating the quantity of ore, only this visible depth has been taken into consideration. In case of some of the plateau deposits an exception has been made by giving them a depth of only ten feet where no prospect pits have been sunk to ascertain the actual depth reached by these flat outcrops. The cubical contents have been calculated by dividing each deposit into a number of sections, each section embracing parts of deposit showing considerable constancy of length, width and height. With the exception of the deposits situated on the plateau, in several cases ore is fully exposed at least on two faces. Length and thickness can be measured in each case provided the latter is not confused with the width of the outcrop. In at least one previous estimate of the quantity of ore available from the Sandur deposits, the thickness has been measured across the strike. Such a step is permissible in case of vertical strata. As applied to the deposits under consideration, such measurement is found to give a greatly exaggerated idea of the actual thickness, for here we have to deal with inclined strata, and in estimating the thickness, it must be based on the well-known relationship between dip and thickness. The relation of density, porosity and moisture to the specific volume [1] of ores is a factor which also must not be lost sight of. The schistosity of the Sandur ores gives rise to open spaces between each lamina. Besides the ore contains cavities which affect the specific gravity to a marked extent. To arrive at an estimate approaching correctness, specific gravity of type ores have to be determined as far as practicable and errors due to porosity and moisture eliminated. The divergence of the specific gravity, porosity and moisture in Sandur ores may be realised from the following determination of type specimens made at the request of the author by Mr. D. Hooper, Curator of the Industrial Section of the Indian Museum. These specimens represent the extreme character of the ores. One of these (No. 1) is highly compact psilomelane exhibiting schistosity to a minor extent. This is representative of the bulk of ore of the Kammat Haruvu deposits. The second specimen is characteristic of several deposits containing somewhat porous psilomelane, highly schistose and containing drusy cavities and inclusions of wad.

TYPE SPECIMENS.		No. 1.	No. 2.
Moisture	..	·335	·189
Porosity	..	4·39	9·69
Specific Gravity	..	4·05	3·74

Allowance should also be made for the inclusions of phyllite, limonite and hematite. After careful consideration of the various factors, the author has come to the conclusion that calculation based on a ratio of 9 cubic feet per ton of ore *in situ* is likely to give a fairly correct estimate of the quantity of marketable ore available from

[1] This subject has been lucidly treated by Mr. Warren J. Mead in "Economic Geology," vol. iii, No 4, pp. 319–325.

the Kammat Haruvu deposits.[1] The following figures have been obtained by careful measurements and calculation. Only those deposits which are most prominent and which can be measured without the need of any assumption have been included. Apparently extensive ore-bodies which are obscured by heavy residuary mantle have not been taken into account. Thus the great bands of ore which are imperfectly exposed on the Karadi Badsala Kativi have been entirely left out of this estimate. The calculated tonnage denotes the minimum quantity of ore which can be easily won. The total ore-reserves of the Kammat Haruvu area is far in excess. But in the absence of extensive development work, it will be idle to exaggerate their value by calculations on imaginary data.

MINIMUM YIELD FROM SOME OF THE MANGANESE-ORE DEPOSITS IN THE KAMMAT HARUVU AREA.

1.	Mala Kolla Banda	166,666	tons.
2.	Jaldi Kolla	45,936	,,
3.	Kenchamaon Doni deposits	24,228	,,
4.	Durgamma Kolla Group	273,884	,,
5.	Joganna Aditha Kolla Haruvu	8,333	,,
6.	,, ,, ,, Kativi	243,833	,,
7.	Yerin Dari	138,888	,,
8.	Kanakeri Waday	4,166	,,
9.	Hunasi Marad Kativi	200,880	,,
10.	Badapatti Bandi	72,303	,,
11.	Ellakal Gadday	52,777	,,
12.	Nagappana Banda	31,555	,,
13.	Galay Banda	43,333	,,
	Total	1,306,782	,,

[1] The weighment of quantity of ore excavated from measured pits sunk at intervals on ore-bodies is one of the safest methods for basing calculation as to actual available quantity.

(96) Economic importance of the deposit.

The early notices of the manganese-ore occurrences in the Sandur State were naturally limited to a fragmentary knowledge of a few imperfectly explored localities. In the light of recent discoveries and present development, the importance of the deposits is greatly enhanced. Whether we consider the persistence of the ore-bodies at intervals throughout a belt of at least twenty miles or the extraordinary development of individual ore-bodies, the productivity of the area becomes apparent even to casual observers. It is true that while in isolated cliff exposures the deposits are fully exposed to a depth of nearly one hundred feet, they generally lack in persistency in their downward extension. But this fact alone cannot minimise their importance, for it is counterbalanced by the remarkable horizontal distribution and great width attained by a large number of deposits. The quantity of ore exposed fully in sight in the Sandur deposits will satisfy any impartial observer as to the producing capacity of the local deposits. Granting their shallowness, the outcrops alone will yield not less than a million tons of marketable ore. When it is said that this quantity can be raised simply by blasting and breaking the ore without the removal of any over-burden, then the quantity of ore fully exposed in these outcrops will be realised to some extent. But the quantity available from the outcrops is a mere fraction of what lies hidden even if the calculation is based by giving an average depth of ten feet to the deposits, although it is certain that in many cases the depth attained by the ore-bodies is much greater. Observers are not unanimous as to the quantity of ore contained in the Sandur deposits. Estimating the total quantity of ore, one authority has arrived at the colossal figure of 60,000,000 tons. Another observer computed the productive capacity of the group of deposits in Durgamma Kolla alone at 8,000,000 tons. Whether these estimations are correct or exaggerated does not alter the actual value of the deposits. The fact remains that the Sandur deposits comprise some of the most extensive manganese-ore deposits of their kind and, area for area, they probably contain the largest manganese-ore reserve so far found. The most conservative but careful estimate will not place the total amount of ore from the Sandur area at less than ten million tons. Supposing this to be the limit of the yielding capacity, it represents twice the amount of the total production of all the Russian centres of manganese mining industry in the Caucasus, Southern Russia and Ural for a period of 21 years from 1885 to 1905.[1] This is in strong contrast to what the writer has been told by a prominent man in the manganese business that one million tons of ore in a single or series of deposits are quite sufficient to satisfy the most exacting financiers in the line, and quantities above one million tons do not enter into their consideration. While the bulk of the Sandur manganese-ores contain a rather high percentage of iron, it cannot certainly be classed as manganiferous iron-ore. The fact is that there is an immense quantity of high grade ore in the Sandur deposits, although the quantity of low grade manganese-ore proper may be greater. There is no lack of first and second grade ore whatever may be the opinion of interested parties. The chief point which depreciates the economic importance of the Sandur manganese ore deposits is to be sought for in their natural environ-

[1] "Manganese-Ores", by John Birkinbine in 'Mineral Resources of the United States" 1905, p. 105.

ment. The peculiar conditions under which they have to be worked have greatly retarded progressive development. The situation of the deposits in an almost waterless tract on hills of high elevation, rendering them comparatively inaccessible in many cases, the difficulty of transport, scarcity of labour in a sparsely populated agricultural district, the unfitnes of local labour for heavy mining work, adverse climatic conditions unsuited to miners coming from the plains, render the economic exploitation of these deposits a difficult problem and an expensive undertaking.

VIII.—MISCELLANEOUS NOTES.

I.—STALACTITIC, CONCRETIONARY AND OOLITIC MANGANIFEROUS FORMATIONS.

(97) Stalactites and concretions.

In deposits which contain numberless "spaces of dissolution," it is natural to find stalactitic growths. The occurrence of drusy cavities in the Sandur deposits has already been described. Where the cavities have been left open under suitable conditions redeposition of manganese and iron precipitates have taken place in stalactitic forms. The stalactites vary in size and in composition. Psilomelane in rod-like form suspended from the roof of small cavities is frequent in some deposits. Sometimes the stalactites show concentric deposition, either limonite or psilomelane forming the core and alternating with each other. Small beautiful stalactites, with cylindrical core of compact psilomelane and outer crust of calcium carbonate showing radiated fibrous structure, have been found in the Ramandrug deposits. Stalactites of hydrous oxide of iron also occur in the same area. Sometimes stalactites with cores of psilomelane encrusted with botryoidal limonite attain to considerable size. Specimens have been found showing the passage of limonite into psilomelane. It may be mentioned here that in a cave in the Sanna Sil Haru hill several stalactites of calcite up to 1½ foot long were found. Stalactites are not so abundant as concretions of manganese which are plentiful in the neighbourhood of some of the deposits. The footpath from Kumaraswami temple leading to the Tappal Paddi deposit and the foot of the cliff deposit at Subrayanhalli Neerkolla are among the localities where innumerable interesting specimens of concretionary manganese can be seen. Most of those examined by the writer were formed round quartz nuclei. They are mostly spherical or ellipsoid These generally exhibit concentric structure which is not clearly noticeable in the irregular and complex forms with phantastic shapes. Concretions of red clay iron also occur. Sometimes these have been formed round original manganiferous concretions. Some of the concretions with branches show considerable symmetry. There can be little doubt that many of these concretions have been formed by the accumulations of manganiferous precipitate collected round the central nucleus. Concretions in place also occur These are the results of segregation and growth of manganiferous particles. Examples of this kind are to be seen among other localities in the Naraindevarkera road cutting in the Mavinmarad Kolla of Ramandrug Hill. The manganiferous concretions and stalactites of the Sandur area have been utilized in a special way by the Boyas, which has probably its counterpart in a similar use of ammonites by a certain class of devout Hindus as a God known as Saligram.[1] The peculiar structure of some

1 "Ayeen Akbery or the Institutes of the Emperor Akbar"—Gladwin's Translation, vol. ii, p. 29.

W. T. Blanford, F.R.S., in the Records of the Geological Survey of India, vol. xxxi, Part I.

stalactites and concretions evidently appealed to their imagination for they have consecrated some of these and worship them as gods and goddesses with the usual offer of sacrifices.

(98) Oolitic Manganiferous formations.

The principal oolitic manganiferous formations of the area have already been described. The oolitic deposits with a few exceptions are confined to the southern edge of the Kammat Haruvü, where they are found to occupy the highest position in relation to the manganese ore-deposits. The oolites of manganese are closely grouped and are cemented by psilomelane, wad, or a ferruginous medium. Oolitic red hematite which also occurs in close association with the oolitic manganiferous formation is imbedded in either clayey or manganiferous cement. This mode of occurrence is of interest as it indicates genetic relationship. The origin of the oolites is not easy of solution. This formation has been regarded as of sedimentary origin, the oolites having been supposed to have been deposited round central nuclei in shallow waters at the heads of the ravines during the first stage of their excavation round what now forms the southern fringe of the plateau. Another theory considers the oolites as formed by segregative action of manganese minerals sparsely distributed in the country rock.[1] The association of oolitic manganese-

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1 As the oolitic deposits are all found on that edge where the plateau is exposed to violent winds, the following remarks of Darwin from "Volcanic Islands" may be of interest :—

"Von Buch has described a compact limestone at Lanzarote, which seems perfectly to resemble the stalagmitic deposition just mentioned ; it coats pebbles, and in parts is finely oolitic ; it forms a far extended layer from one inch to two or three feet in thickness, and it occurs at the height of 800 feet above the sea, but only on that side of the islands exposed to the violent north-western winds. Von Buch remarks, that it is not found in hollows, but only on the unbroken ore with some of the deposits has been adduced as an evidence of the sedimentary and primary origin of the manganese-ore deposits proper. This interpretation is not based on accurate observation of facts. Where oolitic manganese formations occur in the Sandur State they rest as a capping on the main deposits. It has been found that the oolitic formation and the underlying stratified ore-deposit are unconformable; the former showing almost horizontal bedding, whereas the latter is always inclined at a high angle. This discordance of inclination is accentuated by the occurrence of a peculiar conglomerate, consisting of angular and rounded fragments of hematite and limonite along the unconformable junction.

2.—Flora of the Manganiferous Soil.

(99) Plants typical of manganiferous soil.

At present the forests on the Sandur hills are far from heavily timbered. The trees are of small growth, and except in few localities only the ravines bear somewhat luxuriant vegetation. There is reason to suppose that at one time the hills were well wooded and covered by dense forests. But the reckless destruction of trees for domestic requirements and for fuel for the once flourishing indigenous iron smelting industry has brought about the degeneration of the forest growth, the revival of which is now receiving the earnest consideration of the authorities. The efforts for the conservation of forests have met with some success. Although

and inclined surfaces of the mountain. He believes that it has been deposited by the spray which is borne over the whole island by these violent winds. It appears, however, to me, much more probable that it has been formed, as at St. Helena, by the percolation of water through finely comminuted shells: for when sand is blown on a much-exposed coast, it always tends to accumulate on broad, even surfaces, which offer a uniform resistance to the winds."

the ravages of man have given way under strict measures, there are other factors which are beyond human control. The devastating forest fires which occur periodically and the marked diminution in the rainfall in successive years are greatly hampering effective conservation. Most of the plateaus are bare of vegetation where covered by heavy cappings of laterite. Denuding agencies are reducing the thickness of soil year by year, and this removal has proceeded so far in certain areas that the underlying rocks have been fully exposed. Such denudation is specially marked in deforested area. That the richness once possessed by the soil of the plateaus is getting impoverished with the progress of time is established by the fact that the present cultivated area on the Kammat Haruvu and on the Subrayanhalli plateau is a mere fraction of what it was before. The rich red loam formed by the decomposition of ferruginous schists no longer cover wide stretches of land. In many places the forests are so open that the soil cannot retain the moisture for a sufficient length of time. This arid state is in contrast to the high moisture content of the soil in the immediate vicinity of the manganese-ore deposits which are frequently clothed with abundant plant life. Whether this luxuriance of vegetation is directly due to any proportion of manganese present in the soil has not been determined. But it is certain that the manganiferous soil is eminently suitable for the growth of certain plants which prefer this kind of soil to any other. The plants growing on the slopes of Joganna Aditha Kolla are typical of the flora of manganiferous soil in the Sandur hills. Specimens of the soil which has a blackish appearance readily give reaction for manganese. The leaves, bark and heart wood of some of these plants have been tested and the presence of manganese has been detected. The following is a list of plants which appear to be typical of the flora of manganiferous soil:—

1. Lantana indica.	7. Buchanania latifolia.
2 Breynia augustifolia.	8. Grewia asiatica.
3. Diospyros melanoxylon.	9. Streblus aspera.
4. Ficus retusa.	10. Phyllanthus emblica.
5. Sterculia urens.	11. Dalbergia latifolia.
6. Sterculia vilosa.	12. Euphorbia latifolia.

Sandal trees (*Santalum album*) have been noticed growing on some of the Ramandrug and Errakan Muli ore-outcrops.

(100) Manganiferous lichen.

By far the most interesting vegetable growth intimately associated with the ore-bodies is a lichen which has been proved to be invariably manganiferous. This lichen conspicuously covers many of the manganese ore-outcrops in the Sandur State. So far as the writer's observations go, it does not grow on any other rock. Several manganese outcrops may be easily made out by this characteristic growth. Mr. I. H. Burkill, Reporter on Economic Products to the Government of India, examined specimens of this lichen and identified it as belonging to *parmelia Sp.*, probably *P. latissima*, Fee. A similar lichen is found growing on trees in the Sandur State and also in the forests of the Shimoga District. This is a quite distinct species, as Mr. Burkill identifies it as *Permalia perlata*, Ach. This latter does not contain manganese as a constituent. But the lichen growing on manganese-ore outcrops invariably contains traces of that metal. Mr. Hooper analysed specimens of both with the above result. The author has tested the ash of the manganiferous lichen by fusing with sodium carbonate and potassium nitrate mixture, when the characteristic green coloration was produced. Needless to state that in all cases, the test was applied after thoroughly freeing the lichen from any adhering manganiferous particles.[1]

3.—METALLIC CONTENTS AND FLOW OF SPRINGS.

(101) Durgamma Kolla spring.

The springs of the Sandur area afford an interesting subject for study. Most of them flow out from the ravines on the outer side of the western and eastern arm of the Sandur syncline, and there are only a few within the synclinal basin itself. Nearly all are situated approximately at the same level about three hundred feet below the summit of the hills. They take rise from the apex of ravines and many of them sink into the ground not far from their source. Only a few which have sufficient flowage traverse considerable distances before they fall into hill streams or nullahs. The springs at Durgamma Kolla, Subrayanhalli Neer Kolla and Shankar Kolla belong to this class. The spring at Durgamma Kolla is notable for its comparatively heavy flow of water of the purest description. On its downward course it forms cascades and sheets of water amidst beautiful forest scenery.

(102) Metallic contents of its water.

The water of Durgamma Kolla is highly esteemed for its limpidity, purity and taste. A microscopical examination showed that it is singularly free from suspended impurities and lower organisms. As the spring is situated in close proximity to manganese-ore deposits its water has been analysed, to find out whether managanese is present. Dr. S. B. Ghosh, Analyst to the Corporation of Calcutta, undertook the

[1] It is interesting to note that this manganiferous lichen is extensively used in some parts of Southern India for flavouring foodstuffs. The Canarese people call it "Kallu hoo." The non-manganiferous lichen is not at all in demand although it strongly resembles the other in outward appearance.

analysis of Durgamma Kolla water at the request of the writer, and has found that the total solid in the spring water amounts to 7 grains per gallon of water Dr. Ghose has also been able to detect the presence of manganese in appreciable quantity. This explains the interesting phenomena observed during a study of the spring. It has been noticed that in the immediate vicinity of the place whence the water emerges out of the hillside, there is a striking deposit of limonite in course of formation. About three furlongs further down where the stream formed by the spring water crosses the base of Kalhutty Marad Tattu, there is a small superficial deposit of impure manganese oxide on the left bank of the stream. In all probability the occurrence of the encrustations of limonite and of manganese oxide is due to the oxidation and precipitation of the iron and manganese held in solution by the spring water. Where the spring emerges the iron is precipitated as ferric hydroxide on coming in contact with the air. But manganese remains in solution much longer and is carried farther, when under suitable conditions of temperature it is precipitated. C. R. Fresenius has previously observed a similar phenomena in connection with the thermal springs of Weisbaden.[1]

(103) Ferruginous character of Ramandrug Springs.

A number of springs are known to exist in the ravines of Ramandrug Hill. The most important are those below the barracks and near the villages. These two springs supply a sufficient quantity of water for the requirements of the inhabitants. A spring flows into Mavinmarad Kolla just by the side of the Naraindevar-

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[1] Quoted by R. A. F. Penrose, Jr., Ph.D., in the "Annual Report of the Geological Survey of Arkansas," vol. i, p. 553, from Jahrb. des Vereins f. Naturkunde in Herz. Nassau, vol. vi, p. 160 (Bischof).

kera ghat. There is another spring which is on a higher level near the second mile-stone. The water of this is distinctly ferruginous. About a mile south-east of the old tank below the ruined citadel of Ramandrug there is a feeble spring the water of which is so charged with iron, that if kept for some time in an open vessel a small quantity of a red precipitate, which gives distinct reaction for iron, collects in the bottom.

(104) Variation of flowage.

The local people state that the quantity of water flowing from a spring is increased if the forest in the immediate vicinity is on fire. Although not quantitatively tested this statement appears to be based on fact. Whether the rapid discharge of water is due to barometric conditions, temporarily induced by the effects of the fire on the atmosphere, or to the expansion of air in underground capillary pores and consequently intensified effects of hydrostatic pressure on the movement of the ground water, is worthy of investigation. Under ordinary conditions fluctuations in the rate of flowage of some springs have also been noticed. This may be due to the variation of temperature and pressure of air confined in the interstices and pores of rocks.

IX.—ORIGIN OF THE MANGANESE-ORE DEPOSITS.

I.—GENERAL FEATURES OF THE ORE-DEPOSITS OTHER THAN TALUS ORE-ACCUMULATIONS.

(105) Origin of deposits —A field for controversy.

The genesis of the manganese-ore deposits of the Sandur State has been the subject of speculation, and more than one theory has been evolved to account for the origin of the ore-bodies.

Of the various hypotheses propounded from time to time, only two have survived to dominate the field of controversy. One of these advocates the contemporaneous origin of the ore-deposits, while the other maintains that the deposits were formed at a much later period than the enclosing rocks and are essentially the result of replacement of the country rock by metasomatic action. Dr L. L. Fermor is the foremost exponent of the latter theory, and although he has a number of adherents there are not a few who are of opinion that the deposits are syngenetic and the theory of the origin of the Sandur deposits thus still remains a subject of open controversy. Out of the numerous manganese ore-deposits in the State, attempt has been made to prove only a few, and it has been said that, until further development, it is impossible to place any theory on a sound basis. Yet the deposits present features significant and unmistakable which supply the key to their origin. The solution of the problem of ore-genesis is dependent on the right interpretation of facts. The writer merely confines his remarks to actual observations made during a study of the deposits and gives the results for what they are worth

(106) Situation of the ore-deposits.

With the exception of the low level deposits at Subrayanhalli Neer Kolla, Halli Marad Doni, Basiri Maridi Kativi and a few other localities, the manganese-ore deposits of the Sandur State are invariably situated on the top of the ridges at an elevation of over 2,600 feet above the sea level. These high level deposits may be subdivided into two classes, namely, the plateau deposits and those which are situated immediately on the edge of the plateau. The former appear above the surface of the plateaus and are marked by outcrops of ore protruding through the alluvium or surrounding laterite or brecciated hematite or limonite cappings. The outcrops rise very frequently to a height of a few feet above the level of the surrounding land and take the shape of bands, and on several plateaus a series of ore-bands are found to occupy a parallel position in relation to each other and to the enclosing rocks. When the outcrop of ore presents a lenticular outline close inspection added by prospecting work seldom fails to reveal its sharply defined banded character, uniformity of width and horizontal extension, which are obscured by patches of ferruginous capping or of residuary mantle. The second class embraces those deposits which are exposed just on the edge of the plateaus from where the hill-slope begins. In the majority of cases these deposits form cliff-like exposures and not a few of them show extraordinary vertical and horizontal extensions. These mainly present the characteristics of tabular ore-deposits.

(107) Mode of occurrence of ore.

The ore occurs almost without exception as stratiform masses always following the foliation, flexures and crumplings of the enclosing rocks and never branching out into the adjoining strata. In isolated instances where the ore is found to fill fissures and to branch out, it is of secondary origin, being derived from the main deposits. As defined by B. Von Cotta,[1] "Accumulations of ore, which lie parallel to the stratification or foliation of the rock enclosing them, consequently forming one or more subordinate layers between any stratified or foliated (schistose) rock, are called ore beds." The manganese ore-deposits of the Sandur State fall within the scope of this definition and are

[1] B. Von Cotta: "Die Lehre Von den Erzlagerstatten," Prime's translation, p. 17. Also in "The Nature of Ore Deposits" by Dr. Richard Beck, translated and revised by Walter Horvey Weed, E.M., p. 49.

examples of bedded deposits. This is the view held by those who maintain the theory of the contemporaneous origin. On the assumption that the deposits have been formed by the replacement of the country rock in place, only the original layer of rock which has undergone chemical substitution is a true bed. Opinion, again, differs as regards the interbedded nature of these manganese-ore deposits. As layers of argillaceous schist, hematite or limonite are always found intercalated and alternating with the manganese-ore beds and give rise to a banded appearance on an exaggerated scale due to their parallelism, it is not clear how there can be any dispute as to their interbedded character as the intervening layers either underlie the manganese-ore beds or are overlain by them. It seems that controversy as to the origin of the ore deposits and objection to regard the Sandur deposits as bedded or interbedded rest chiefly on the assumption that a true bed must extend from one to the other arm of a synclinorium without interruption, and as the Sandur manganese-ore deposits do not extend vertically to an indefinite distance, always merging into the schist downwards, they cannot be classed as beds or interbedded deposits. If this view be correct then very few of the rocks in the Sandur area which are of undoubted sedimentary origin are bedded according to this interpretation, as they frequently lack in persistence and grade into one another. It is superfluous to state that such assumption does not take into consideration the overlapping and thinning of beds and lateral gradation during the process of formation of sedimentary deposits on the floor of the sea.

(108) Ore bands.

The manganese-ore deposits under consideration have been variously designated as seams, bedded veins, lenticles, etc. The use of such terms has frequently been arbitrary without proper reference to the shape and nature of the deposits. Such arbitrary classification is common among the miners in this country, and "reef" is a favorite term which can be applied according to them to any deposit provided it is sufficiently large or even if it holds the remote prospect of being so. It is needless to assign the reasons for the unsuitability of this term being applied to manganese-ore deposits proper. The term "seam" is not also appropriate in spite of the great horizontal distribution and constant thickness of the Sandur deposits. The deposits have often been called "lenticular." The applicability of this term is also doubtful as, although some of the deposits present a lenticular shape on superficial examination, they really form beds of considerable horizontal distribution without great variation in thickness. Some of the deposits show great thickness and comparatively small horizontal extension owing to their longer dimension having been subjected to erosive action. But as they do not wedge out rapidly in all directions and as they maintain almost constant thickness in depth, before they pass into the underlying rock, the term "lens" is inapplicable to them. The deposits may be termed "bedded veins" according to the theory of replacement, as they are conformable with the foliation of the country rock, a characteristic wanting in true veins. But this classification is also hardly suitable. From what has been related in the description of the ore-deposits, it follows that the deposits form regular ore masses of immense proportions, presenting the outline of tabular ore-bodies, which are intercalated and folded up with the adjacent strata in such a way as to give rise to well-defined banded appearance. This is accentuated by the extraordinary persistence in horizontal distribution and by the uniformity of thickness throughout the extension of individual ore-masses and also by the existence of parallel deposits side by side with the alternating layers of argillites and hematite. Under these conditions they present a striking banded appearance in relief. Hence the designation of "Ore bands" or "banded deposits" is appropriate and may receive general acceptance.

(109) Summary of the chief characteristics of the deposits.

To sum up, it must be admitted that the distinguishing features of the Sandur manganese-ore deposits are their bedded and banded appearance, their absolute conformity with the adjacent strata and the remarkable persistency of strike and dip. With the exception of the low-level deposits, they are always situated on the top of the hills. Although several beds are exposed just on the edge of high plateaus, it must not be forgotten that a great number also crops out in the interior of the plateaus away from the hill slopes. The deposits occur in definite geological horizons at the base of the banded jasper and above the gritty ferruginous schist. The alternation with bands of hematite, limonite and phyllite is marked. The majority of the deposits are so well-defined and so regularly distributed in the manganese ore-bearing formation that it is difficult to explain their origin by replacement processes which would have given rise to irregular deposits. A complete and gradual transition series cannot be traced from unaltered phyllite to manganese-ore. The boundaries between the alternate layers of phyllite and manganese-ore are sharp and irregular boundaries are absent. There is also nothing to indicate deposition in pitching troughs with impervious basement or in fissures. Although the ore-bodies show extraordinary horizontal distribution and sometimes considerable width their extension downwards is limited. They almost always pass downward into the phyllite with absolute conformability, the boundary being well-defined but undulatory. The deposits do not branch out into the adjacent or underlying strata. Inclusions of phyllite are sometimes present in the ore-bodies. These inclusions vary greatly in size. Veins of limonite or hematite also occur in some of the deposits. Vugs filled with limonite or hematite showing "crustification" have been noticed in some cases. The deposits are almost invariably traversed by tension joints which have split up the ore-bodies into rectangular blocks. The joint planes are not ore-bearing. Minute fissures filled with manganese minerals and drusy cavities occur frequently as a result of secondary enrichment. Sometimes the fissures contain pisolitic or lateritic encrustations. The great bulk of the ore-bodies consists of psilomelane, the amorphous and compact structure of which supplies a sharp contrast to the porous country rock which essentially consists of fragments of clastic origin.

2.—Discussion of alternative Hypotheses based on Structural Evidence.

(110) Weathering—Cause of formation of Sandur ore-deposits.

It has already been stated that Sir Thomas Holland in his "General Report of the Geological Survey of India for the year 1907" says that, according to Mr. Fermor, "the manganese and associated iron-ores are formed as weather products from hematite schists similar to those on which the ore-deposits now lie." In a summary of departmental work it is idle to expect a full exposition of the chain of evidence which has led to the description of the ore-deposits under consideration as "weather products." Consequently, the following remarks of the writer must not be taken as a criticism of Mr. Fermor's views in any way. As the manganese-ore deposits under consideration have often been characterised as weather-products, it is not unreasonable to discuss how far such an assumption is valid. Weathering, as defined by Lindgren,[1] includes "the changes of rocks near the surface in cohesion and composition, due to the decomposing and oxidizing action of percolating waters above the permanent water-level. The tendency of weathering is to destroy the rock as a geological unit." It involves physical deterioration or chemical decomposition or a combination of both, and is invariably accompanied by the destruction of the structure of the rocks which come under its influence. As the generally accepted definition of weathering does not presuppose the molecular substitution of decomposing constituents, and as manganese and iron-ores are said to have been derived from hematitic schists and slates, and as the ore-bodies thus formed essentially consist of the metalliferous minerals, their formation must have not only been accompanied by extreme decomposition but must have resulted in the expulsion of all non-metalliferous minerals which mainly constituted the slates and schists from which the ore-deposits are supposed to have been formed by weathering. Such a process of decomposition and concentration of the ore must be accompanied by change in volume and cannot be effected without the effacement of the original characteristics of the rocks involved, which carried the metalliferous minerals as minor constituents of insignificant proportion as disseminations. Consequently, the obliteration of the

[1] Waldemar Lindgren—"Metasomatic Process in Fissure-Veins" in the Genesis of Ore-Deposits, p. 506.

schistose character of the original rock would have been a natural consequence, as it is more than improbable that a rock of complex composition should be transformed into a manganese-ore deposit retaining the shape structure and volume of the original rock in spite of profound alterations caused by the entire removal of all the principal constituents. On the strength of the evidence of structural alteration which must accompany weathering action, the view of the origin of the ore-deposits under consideration, which show remarkable structural details, as ultimate products of weathering cannot be sustained. Besides, the hematitic or manganiferous schists and slates are essentially a phase of the argillites or phyllites containing small amounts of manganese and iron oxide. To quote Merrill,[1] such argillites "as a rule are among the most indestructible of rocks," being themselves composed of the fragmental remains of the pre-existing rocks, which withstood the effects of disintegrating and decomposing agencies and were transported and laid down in the bottom of the sea, from which they emerged as consolidated rock masses. Thus it appears that the conception of the decomposibility of argillites due to weathering leading to profound alteration, and at the same time giving rise to manganese-ore deposits with preservation of original structure, is based on an oversight of the character of such rocks.

(III) Segregation of Manganese Minerals and its bearing on the theory of origin.

It is admitted that in the vicinity of some manganese ore-deposits portions of the country rock show signs of alteration. Exposed sections and loose blocks also not only clearly indicate that they contain manganese

[1] George P. Merrill—Rocks, Rock-Weathering and Soils, p. 229.

minerals (probably as an original constituent), but signs of decided segregation of individual minerals are apparent in many cases. Where the process has not proceeded far the rock almost retains its original character modified by metamorphism and disintegrating influences. At places the exposures of the red phyllite associated with ferruginous quartzose schist show that segregation of the constituent minerals has taken place, accompanied by a tendency towards alteration in the co'our and texture of the rock. Microscopic examination of thin sections revealed a marked change consequent on the development o' the segregative action. In specimens representative of the intermediate stages of alteration we find an almost complete separation of the manganese and iron minerals from the main mass, which has lost its original red colour and has assumed a greyish yellow tinge. But the metalliferous mineral aggregates are still found in a mixed state, the minute red grains of hematite being easily recognised from the black manganese minerals. At a later stage further concentration and segregation aided by metasomatic action induce the development of zonal structure of the iron and manganese minerals. It is seen that the former has lost its red colour and has become yellow, while the manganiferous zone retains its original colour but begins to show development of minute crystals in a few places. At a final stage it is found that the entire separation of the metalliferous and non-metalliferous constituents of the original rock has taken place. The rock has become almost white in colour, and the iron minerals have segregated and altered into limonite, wh'ch is found to occur in close proximity to the area covered by manganese minerals, consisting mainly of psilomelane with a small proportion of braunite. The area occupied by limonite is frequently larger than that of manganese ore. But in every case the quantity of rock material is in great excess. After the above evidence it seems that there can hardly be any doubt as to the ability of the original manganiferous and ferruginous rock to contribute to the formation of manganese and iron ores, and what is true of isolated exposures or hand specimens may be true of large masses of the same rock which under exactly similar influences may give rise to large deposits of manganese-ore. But on analysing the structural features of the sections and loose specimens of the original rock undergoing alteration as sketched above, it is seen that the original manganiferous rock as altered by the abstraction and migration of the metalliferous constituents shows conspicuous modification of structure during the different stages of alteration. In specimens which show the final phase the texture and the schistose structure of the rock have been destroyed owing to the differential movement of the particles under the combined influence of segregative action and disintegration. If the process above-delineated was responsible for the formation of large ore-deposits, such ore-bodies would be devoid of the schistose structure, and this is evidenced by the small lenticular patches and concretions of ore which are associated with the country rock at places. Such scattered lenticles and concretions comprise portions of successive laminæ of the original rock which has lost its schistosity and has given place to homogeneous ore in those places which have been affected by segregative action. The ore does not exist in thin leaves which preserve their continuity. The accompanying photographic illustration (Plate 16) will afford better means for judging the correctness of the author's conclusions than a sketch or a hypothetical drawing.

(112) Manganiferous laterite as distinct from manganese-ore deposits proper.

The relation of the overlying manganiferous laterite with the manganese ore-deposits proper as observed in isolated areas in the Sandur Hills is a superficial one. This manganiferous laterite the importance of which is negligible is undoubtedly of secondary origin, being formed in place by the segregation of the manganiferous, ferruginous and aluminous contents of the original rock under disintegrating and recomposing influences. This kind of manganiferous laterite shows some development only on the Ramandrug plateau. There it has been formed in the upper part of the manganese ore-deposits in the zone of impoverishment where the layers of manganese-ore merge into the schist. The manganiferous schist which is a phase of the argillite originally bordering the depressions in which sedimentation of the ore took place shows marked alteration. Segregative replacement at places has produced under favourable conditions powerful effects, an almost complete separation of the metalliferous contents being the result. The lateritic rock is riddled with cavities and tubules and the manganiferous and ferruginous constituents are present in patches in a ground mass of yellow aluminous schist. Manganese is present in the form of wad and rarely as a superior ore. Hydration of the ferruginous minerals has produced abundance of yellow ochreous inclusions which predominate in the schist. Where the laterite has acquired a highly manganiferous or limonitic character producing compact ore without hollows by further concentration, the laminated structure has been obliterated—an indication which is wanting in the contiguous manganese ore bed proper where even the close textured ore shows schistosity—a structure which must have been produced by the metamorphism of the original layer of ore sediment, and which would have been effaced if the main ore-deposits were produced by the same agency as the manganiferous laterite. Hence it is that the lateritic origin of the principal Sandur deposits appears to be untenable.

(113) Criteria of metasomatism.

In one of his illuminating papers on ore-deposits, Lindgren[1] remarks: "It is not always easy to be sure whether metasomatic action really has taken place, and in deciding the question the greatest caution must be observed. The mere occurrence of two minerals together by no means proves that one has been derived from the other. The chief difficulty is to draw the distinction between molecular processes involving simultaneous dissolution and precipitation on the other." Lindgren endorses the opinion of Becker that "the theory of the substitution of ore for rock is to be accepted only when there is definite evidence of pseudomorphic, molecular replacement." If this test be applied to the Sandur deposits, then the theory that the ore bodies are the results of the replacement of the country rock will be negatived as evidence of pseudomorphous replacement is lacking. The granular and crystalline structure of the constituent minerals of the country rock would have been preserved in the ore if simultaneous dissolution and precipitation had taken place. While the phyllite which forms the country rock though considerably metamorphosed, is composed of mechanical sediments and contains fragments of quartz and felspar with crystalline outline, the ore essentially consists of psilomelane invariably characterised by amorphous texture. As the ore bodies show schistosity to a high degree the theory of previous dissolution of the

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[1] Genesis of Ore-deposits, pp. 515—517.

country rock and subsequent deposition of ore cannot be maintained. Moreover, replacement takes place when the conditions for reaction are favourable, as in the case of a soluble precipitate like limestone, which is susceptible of molecular substitution. In a rock of complex composition like the phyllites it is doubtful how far such interaction is possible and it is unlikely that molecular interchange takes place. According to Emmons, the criteria of metasomatism consist of (1) absence of breccias of country rock cemented by vein material; (2) great irregularity in the width of the ore-bodies; (3) general lack of definition between ore-body and wall rock. These characteristics also are wanting in the Sandur deposits.

(11d) Inclusion of country rock.

In several manganese-ore deposits of the Sandur State, inclusions of phyllite have been observed in the ore. These inclusions vary in dimensions. In isolated instances they are as wide as two or three feet. But very frequently they are so small as to be hardly discernible with the unaided eye. These inclusions of phyllite have been taken by the advocates of the theory of metasomatic origin as an unmistakeable sign of replacement, as they contend that the manganese-ore has replaced the phyllite, fragments of which still remain unaltered. Prof. Henry Louis,[1] referring to deposits which contain "fragments of the country rock both from the foot and hanging walls," says that such deposits "cannot be regarded as contemporaneous with enclosing strata, but are evidently of subsequent formation." He also states "that certain deposits, however, somewhat similar in character have probably had a different origin, and may be regarded as beds formed prior to

[1] A Treatise on Ore Deposits by J. A. Phillips, F.R.S., and Henry Louis, M.A., A.R.S.M., F.I.C., F.G.S., etc. (1896), p. 153.

the deposition of the overlying rock.'' On the same subject, while discussing criterea of metasomatism, Lindgren observes that "the occurrence of remaining nuclei of unaltered rock is sometimes an available criterion, but it must be used with caution, and probably has given rise to misinterpretations." Referring to the Leadville deposits, Posepny[1] says: "When we read, however, of great 'horses' of country rock, encountered in the midst of the ore, we must believe that the deposit is due not so much to a metasomatic replacement of the limestone as to the filling of spaces of dissolution; and hence it should exhibit the characteristic sign of such a filling, namely, crustification." Since the main mass of ore-bodies constituting the Sandur deposits shows no signs of crustification, it may be considered that the ore was not deposited in pre-existing spaces of dissolution or fissure. Moreover, careful examination of the inclusions of phyllite shows that they retain remarkably sharply-defined angular structure. To quote Purington:[2] "It is impossible to conceive how a corrosion of the country rock would have taken place without a rounding off of the corners and disappearance of the angular character of the included fragments." It is also improbable that the intense metasomatic action which is capable of producing such profound alteration of the country rock, converting millions of cubic feet of it into manganese-ore, should not leave appreciable traces of action on the wall rock in immediate contact with the zone of replacement. The phyllite which forms a sharp boundary on either side of the manganese-ore bands, as seen at some exposures,

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1 The Genesis of Ore-Deposits, p. 108.

2 Chester Wells Purington—Preliminary Report on the Mining Industries of the Telluride Quadrangle, Colorado, in the "Eighteenth Annual Report of the United States Geological Survey," part III, p. 800.

does not bear even the minutest trace of metasomatic action and remains perfectly unaltered. These indications point to original deposition of the manganese-ore in conformable strata. The inclusions of phyllite are evidently the result of the introduction of clastic material from the adjacent area during the precipitation and subsidence of the manganese minerals in the sea basin.

(115) Selective precipitation—its bearing on the theory of replacement.

According to the theory of molecular substitution of ore for rock, the original rock must have been identical with the phyllite which is now seen intercalated between the deposits, as fragments of exactly similar rock are still found inside some of the ore, and as, according to this theory, these inclusions prove conclusively the metasomatic origin of the ore-deposits. This phyllite then must have originally undergone replacement. Rock of identical composition is now seen not only enclosing the manganese-ore deposits and constituting the manganese ore-bearing formation, but is also found alternating with the ore-bands in layers. The presence of fragments of phyllite contained in the ore goes to show (according to the advocates of molecular substitution) that, before replacement took place, the bed of phyllite was a continuous one. Hence it appears that the theory of selective precipitation in accounting for the existence of parallel layers of manganese and iron-ore and phyllite is untenable, because had there been any selective precipitation, the manganese-ore would have been deposited as a continuous layer, as the mineralizing solution would not have attacked the phyllite in such a way as to leave layers of the same rock entirely unaffected between the parallel manganese ore-bands. Even supposing that the existence side by side of bands of manganese and of iron ore is possible through segregative action and rearrangement of individual minerals, it is difficult to realize how layers of phyllite of small thickness will be left between the parallel bands of manganese-ore, formed by the replacement of the identical rock by mineralising solutions which permeated through the entire mass, as it is improbable that a homogenous rock free from fissures will favour flowage along definite trunk channels.

(116) Movement of mineralising solutions.

Since the rocks supposed to have been originally involved in the process of alteration by molecular substitution are no longer horizontal, having been tilted to an almost vertical position, and since the parting planes are consequently inclined at a high angle and the extension of the parting plane is not narrowly limited in their continuity downward, the solution it may be inferred descended along these open spaces and contributed to the growth of the fragments of the manganese minerals. And since the beds of phyllite have great vertical and horizontal distribution and the parting planes are continuous throughout the extension of the beds, the deposits ultimately produced by replacement or by the growth of the mineral nuclei ought to have great lateral as well as vertical and horizontal extension, and above all ought to preserve their continuity without the intervention of completely unaltered rock. How the mineralizing solutions traversed the entire length of the layers of phyllite along definite horizons and left wide intervals between the individual deposits is not easily explained, as the question of selective precipitation cannot arise in the face of the inclusion of unaltered fragments, identical with the "country" rock, which form the continuation and walls of the deposits and which are characterized by cleavage and stratification foliation as well as pore spaces, exactly similar to those of the rock supposed to have undergone replacement It is almost certain that the mineralising solutions did not flow diagonally to the strata. If it had been otherwise then the break between the deposits could have been explained easily. The ore-bodies generally show impoverishment in their downward and upward extension; the central portion of a deposit containing the richest ore—a fact which can be explained according to the theory of sedimentary deposition—as on the margin of the shallow depressions on the sea-floor, in which the manganiferous precipitates subsided, the carrying of and commingling with clastic materials from the surroundings is nothing but a natural consequence of mechanical action which was minimised in the central part of the depression where the metalliferous precipitate was concentrated. Descending or ascending solutions inducing metasomatic action are not capable of effecting enrichment of the core of a deposit, leaving the upper and lower zone comparatively barren. Hence it may be argued that the longitudinal extension of the ore-bodies probably indicates lateral movement of the mineralising solutions which formed the ore-deposits in such a way that their longer dimension is parallel to the strike of the enclosing rocks The stratification and cleavage foliation of the rock undergoing replacement, it may be argued, also influenced the direction of flowage and thus determined the shape of the deposits. But the evidences available sufficiently indicate that the solutions did not attack the country rock at right angles to the strike, and hence the absence of deposits which cross the strata of the original rock diagonally. But the theory of lateral secretion as well as that of ascending and descending solutions cannot be maintained as none of these agencies can effect their passage through a homogeneous rock and replace its constituents only at intervals along definite zones under identical environment, leaving unaltered rock forming the immediate continuation of the ore-deposits

(117) Character of deposits of secondary origin.

While maintaining the primary origin of the majority of the Sandur manganese ore-deposits, it is conceded that there are not a few minor deposits which have been formed by the replacement of the country rock. The ore of such secondary deposits will be found to be massive or concretionary and will rarely show the schistose structure extending throughout the ore mass which is characteristic of all the principal ore-deposits in the Sandur area. Moreover, the ore produced as a result of replacement will seldom fail on close examination to reveal concretionary character, where not affected by profound alteration by secondary enrichment which frequently obliterates original structure and, by the concentration and commingling of mineral particles, produces consolidated ore masses devoid of internal laminated or concretionary structure. But in such cases the ore will generally be found in the shape of nodules or isolated blocks with defined boundaries, and such nodules and blocks may or may not be *in situ* according to absence or otherwise of rock deterioration and displacement. Recent prospecting has revealed the existence of a number of such secondary formations in the vicinity of primary ore deposits. Sometimes they appear at first sight to be the continuation of original ore-bodies. But on careful examination they are found to be derived from the parent bed by mineralising solutions.

3.—THEORY OF DEPOSITION IN A SEA-BASIN.

The theory of contemporaneous sedimentary origin

(118) Theory of syngenetic deposits, etc. Posepny's opposition in the light of recent researches.

of ore-deposits has been rarely advocated since it fell a victim to the pronounced antagonism of Posepny as expressed in his great work the "Genesis of Ore Deposits," which laid the foundation of a new school of organised thought on the science of ore-deposits. Posepny's opposition to the theory of precipitation of metalliferous minerals and the formation of ore-deposits in sea-basins was based on the absence, in his days, of analogy and demonstrative evidence. Since then the elaborate researches of a host of eminent investigators have thrown a flood of light on the nature of marine deposits In his presidential address before the Geological Society of London on the subject of the "Evolution of Petrological Ideas," while considering the sedimentary rocks, Dr. Teall remarks[1]: "Geographical and oceanographical exploration during the latter half of the century have greatly enlarged our conceptions, and given precision and definiteness to ideas that must otherwise have remained vague and uncertain. We now know that ocean basins and desert regions are the principal areas of deposition, and that the rocks which are forming in both these areas have their geological representatives. Ocean-basins form the ultimate receptacle of the mechanical detritus washed down by rivers from areas of open drainage. Areas of open drainage have, as a rule, a moist climate, and the mechanical sediments deposited in the open ocean therefore represent the more or less insoluble residues of the crystalline rocks, and consist largely of such substances as quartz, mica, zircon, rutile, ilmenite, cyanite, hydrated aluminous sili-

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1 Proceedings of the Geological Society, May, 1902, vol. 58, p. lxvi.

cates, and the oxides of iron and manganese." Of late there has been a tendency to revert to the theory of contemporaneous sedimentary origin to explain the genesis of a certain class of ore-deposits. To arrive at a conclusion as to the origin of an ore-deposit, deductions should be based on sound interpretation of facts, and it is necessary to abandon preconceived ideas if facts observed are in direct opposition to such conceptions. Because a great exponent has discredited and discarded the theory of contemporaneous sedimentary origin, because the aid of metasomatic action is frequently invoked now-a-days to account for the majority of ore-deposits, considerations such as these should not fetter any observer who attempts to unravel a problem shrouded in obscurity. Each link in the chain of evidence must be tested and the reasons for and against a theory must be sifted, and each case must be considered solely on its merits. After all, it is more or less impossible to define the exact causes which played a part in the formation of a deposit in ages remote from human knowledge. An attempt is here made to suggest an explanation of the origin of the Sandur manganese ore-deposits. In discussing the validity of the different theories the writer does not pretend that his reading of facts is absolutely devoid of error. A theory is only tentatively advanced to survive or to fall as it deserves.

(119) Origin of the phyllites.

During the pre-Palæozoic age when the sea extended over the greater part of Peninsular India, the basement bed of the Dharwar formation in the Sandur area was submerged in the depths of the Archæan ocean. On this floor the disintegrated remains of an ancient continent began to accumulate. With the progress of ordinary sedimentation there came a period of great volcanic activity of submarine origin. From active volcanic vents showers of detritus succeeded by streams of lava were poured forth. These volcanic products consolidated as horizontal deposits of breccia and as sheets of lava. Derived from the explosive destruction and disintegration of diabase lavas, at a later stage the breccia beds lost their tuffaceous character and original structure, having been subjected to heat, action of water, and dynamic forces. The fine tuffs and the volcanic dust and the disintegration product of the lavas were metamorphosed into pyhllites, some of their contained felspar being converted into mica through intense pressure and shearing during the folding of the strata which now form the Sandur syncline. The close association of some of the phyllites with the interbedded lavas is an evidence of their origin from the destruction of these diabase rocks. It is not contended that all the phyllites of the Sandur area are metamorphosed volcanic product. Some were probably derived from other sources.

(120) Contemporaneous trap flows.

Several exposures of interbedded lavas are seen in the bed of the Narihalla. All the exposures may not represent contemporaneous flows, as some are intrusive and probably of later date. But parallel sheets occur, their dip and strike coinciding with those of the enclosing schists. No exposure of the interbedded sheets has so far been observed in the higher parts of the Sandur hills. With the elevation of the altitude they appear to die out or to merge into the schist. The highest exposure so far detected occurs on the slope of Baray Marad Penta, where it underlies a highly ferruginous slate which lies at the base of the manganese-ore deposits at Gedel Tattu and Seshgiri Haruvu. They are all comparatively fine grained and possess a dull greenish colour. All of them show a more or less jointed structure. In some cases the joint systems divide the rock into rhomboidal prisms interlocking with each other. The rock then shows a marked tendency to cleavage. Such structure is well seen in a bed exposure on the footpath to Kammat Haruvu, by the side of Katar Timman Kolla. This change from a massive to a schistose state with the development of cleavage is exhibited in a remarkable manner by a greenstone schist which is frequently found in association with the interbedded lavas. This rock is probably another phase of the alteration of the lavas through the effects of extreme metamorphism. The lavas occur in various stages of decomposition and are even found unaltered. When well preserved the basic character of the rock is easily recognised. Under the microscope abundance of grains of augite, mixed with plagioclase and iron ores are visible. The plagioclase occurs in irregular splinters and sometimes as lath-shaped crystals. In rare cases the characteristic twinning may be detected. Magnetite occurs in profusion. Minute fragments of iron pyrites are also sometimes readily recognisable. Specimens from a large number of exposures of the interbedded lavas have been tested for managanese. In all cases distinct reaction[1] was obtained thus proving that these rocks

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1 The author refrains from quoting any analytical result. Speaking of the difficulties in correctly determining the percentage of managanese, Hillebrand says: "The gravimetric determination of manganese in small amounts seems to be more of a stumbling block to the average chemist than that of almost any other of the frequently occurring elements met with in mineral analysis. This is due almost always to incomplete prior separation of elements which later suffer coprecipitation with the manganese. The error is therefore a plus one, and often amounts to many times the weight of the manganese actually present." (The Analysis of Silicate and Carbonate Rocks, p. 96.) Washington also comments on this error of comparatively frequent occurrence in his 'Chemical Analysis of Igneous Rocks' (p. 23), and also in the 'Chemical Analysis of Rocks,' pp. 15 and 68.

contain manganese as a constituent—a fact which is significant as to the occurrence of deposits of the same mineral in the same geological horizon.

(121) Sources of the ore.

The origin of the Sandur manganese-ore deposits is to be sought for in the ultimate effects of that igneous activity of which the breccia beds and the sheets of lava were the results. To the disintegration of the manganiferous constituents of these volcanic ejectments is to be attributed the cause of the formation of the manganese-ore deposits. In the abundant presence of manganiferous minerals in the im mense outpourings of basic volcanic materials an explanation is to be found for the extent of the local accumulation of manganese-ore. Ejected from submarine volcanic vents the decomposition of the silicates and other manganiferous minerals contained in the lavas resulted in the liberation of the manganese oxides from hot magmatic solutions. This local supply of manganese from basic igneous rocks was greatly augmented by the decay of an immense mass of volcanic debris which also contained manganiferous constituents. The precipitation of manganese and of iron contributed to the waters of the sea by hot magmatic waters was a parallel process, since both the elements entered into the composition of the products of the igneous activity and since their chemical behaviour was similiar. The manganese in magmatic solution coming in contact with the oxygen contained in the alkaline sea water was precipitated in a hydrated condition, probably as manganous manganic oxide or as colloidal complexes. The iron was precipitated as ferric hydroxide; these precipitates were formed and deposited one after the other. If it were possible for them to form simultaneously in the sea water, their particles must have passed through a selective process, their subsidence being guided by their relative densities, thus separating the deposit of iron from that of manganese. But the thermo-chemical researches of Dieulafait throw much light on the separation of manganese and iron ores and their alternation with each other. Thomsen and Berthelot had come to the conclusion that of a number of possible chemical reactions, that one always takes place which is accompanied by the greatest evolution of heat. Dieulafait[1] has shown that if oxygen acts on a mixture of FeO and MnO, ferric oxide will form first and be the more stable. In case of union with carbon dioxide the manganese compound will be formed first. Dieulafait has also shown that manganese dioxide is the easiest formed compound of manganese. Whether carbon dioxide played any part in the deposition of manganese, or whether the precipitation was due to contact with oxygen, it is idle to speculate.[2] But it will not be absurd to base the theory of the separation of the iron and manganese ore-deposits[3] as seen in the Sandur area on Dieulafait's thermo-chemical arguments. The process of the deposition of the compounds of manganese and iron guided by local currents on the floor of the sea in a definite horizon was not only long continued, but was re-

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1 Compt. Rend. Vol. 101, pp. 609, 644, 676, 1885.

F. W. Clarke—The Data of Geochemistry, pp. 457, 458.

2 The theory of precipitation of manganese through the intervention of marine organisms has been advocated by Buchanan. Although no fossil remains have previously been discovered in the Dharwar Rocks, the author has found traces of organic origin in some of the Sandur rocks, specially in the vicinity of some manganese-ore deposits. It is hoped that the specimens will be described in another place

3 The chemical separation of iron and manganese ore has been fully discussed by Dr. R. A. F. Penrose, Jr., Ph.D., in his monograph on Manganese, forming the 'First Annual Report of the Geological Survey of Arkansas,' vol. i., pp. 569—573, and also in the 'Journal of Geology,' vol. i., No. 4, pp. 356-370.

peated with each cycle of volcanic activity. In the Sandur basin evidence is not wanting to indicate a series of successive periods of volcanic activity. This is represented by the contemporaneous interbedded lavas which make their appearance at intervals. It is surmised that with the recurrence of volcanic cycles the process of separation of manganese and iron minerals contributed to the sea from magmatic hot water was repeated under almost identical conditions, and hence the existence of parallel deposits of ore. The increase of braunite and of silica in deposits which occupy higher position in the ore-horizon and the final appearance of banded jasper are significant features, perhaps not altogether without bearing on the law of succession of lavas, beginning with basic types and passing through less siliceous and more siliceous ones to rocks extremely high in silica.[1]

(122) Subsidence of the metalliferous precipitates; erosion altitude.

The iron and manganese compounds were deposited on the floor of the sea in a definite horizon in successive layers. As has been already stated their disposition was governed by local currents and so led to the linear arrangement of the deposits. The metalliferous precipitates might have settled into hollows on the floor developed in consequence of unequal deposition of mechanical sediments, or it is possible that the superincumbent weight of heavy metalliferous layers made them sink into the sediment which formed the basement bed. In this way the deposits acquired a lenticular disposition with intervention of barren rock between them. The line of demarcation between the layers of manganese and iron-ores probably indicates conditions of precipitation under

[1] Geikie, Sir Archibald,—Anniversary Presidential Address in the Quarterly Journal of the Geological Society—xlviii, p. 178.

minimum variation of temperature. During the precipitation of the metalliferous minerals a certain amount of volcanic debris mingled with the precipitate or extraneous rock materials might have been introduced in the ore lenticles by convection currents or through other mechanical agencies during the sedimentation of the ore. These fragments are now found in the ore-beds as inclusions. In some cases the introduction of clastic materials was so extensive that these ore-bodies are still found in an impoverished state. As volcanic activity did not die out altogether, its gentler manifestation produced irregular cracks in the ore lenticles; these cracks were in many cases filled with ferruginous infiltration from the upper beds, and veins of limonite in the ore bodies were thus formed.[1] Only these veins which were formed before the uplifting of the strata show schistosity; they are in marked contrast with the infiltration veins which were formed subsequent to the upheaval of rocks and which consequently show no sign of schistosity. With the recurrence of the cycle of volcanic activity the deposits were covered by layers of mechanical sediments, which again became the receptacles for a new series of deposits. With the deposition of what is now represented by the banded jasper the process of the formation of metalliferous deposits terminated, and

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[1] It has been already stated that some of the manganese ore-deposits under consideration contain inclusions of phyllite and veins of hematite and limonite. These indications and the finding of beds of conglomerate by Mr. Foote in the Sandur Hills raise the question of deposition in shallow water which would have certainly constituted the best environment for the precipitation of the metalliferous minerals. Commenting on Peter's theory of the origin of Mount Lyell ores. Professor Gregory says: "If the ore mass had been formed in swamps we should have expected to find layers and channels filled with ordinary mechanically formed sediments, due to a temporary cessation of the deposition of the ores and to the occurrence of stream channels through them." The Mount Lyell Mining Field, p. 121.

ordinary sedimentation was resumed, broken by periods of volcanic activity. Ultimately the submerged strata were folded and uplifted and were subjected to the erosive action of the pre-Palæozoic atmosphere. Erosion gradually cut off the top of the anticline, subjacent to the western limb of the Sandur syncline, thus determining the present configuration of the region and exposing the manganese ore-bearing and associated formations. In the process of erosion with the removal of millions of cubic feet of rock the upper portion of the manganese ore-deposits were involved and carried away. The remainder has survived and retained its present upward extension in proportion to the depth reached by erosive influences on the top of the ridges. With the progress of erosion a time came when under favourable conditions lateritisation began to develop on the crest of the ridges, wherever the exposures of the highly ferruginous phyllite were favourable to segregative action and replacement. The development of the great cappings of laterite led to the arrest of erosive action to a great extent and thus determined the present altitude of the main mass of ridges.

(123) Analogy.

If present-day phenomena can be accepted as representing in any way events of the past, the theory delineated above of the Sandur manganese ore-deposits is not without corroborative evidence. The oceanographic and chemical researches of Murray, Thomson, Renard, Irvine and Buchanan have thrown much light on the character of numerous immense accumulations of manganiferous nodules in various parts of the world. Such a formation has been located in the Indian Ocean. It is significant that these manganiferous formations show their strongest development when associated with a peculiar red clay and in areas where the basic series of rock predominate.[1] Sir John Murray is of opinion that manganese occurs plentifully where augitic lavas are abundant. The nodular formations which are now found in the floors of oceans probably represent in a feeble degree a far more intense process which gave rise to extensive deposits in the Archæan ocean. The voluminous precipitation of iron and manganese minerals leading to the formation of extensive deposits in the Archæan ocean is not without parallel in and outside of India. Sir William Dawson advocated the derivation of certain manganese-ore-deposits of Nova Scotia from the decomposition of contemporaneous trap rocks. A similar origin was proposed by Messrs. Gilpin and Mathew for some of the deposits in Canada.[2] Recent researches on the origin of the Lake Superior iron ores show a tendency to revert to the theory of the origin of the ores direct from the greenstone by magmatic solutions.[3]

(124) Secondary enrichment as a factor in ore deposition.

While maintaining that evidence is not lacking to support the theory of primary origin of the majority of the manganese-ore deposits in the Sandur area, it is not denied that the deposits have been subjected to the influence of secondary enrichment, which has left distinct evidence of its effects on the ore-bodies. Although it is evident that change of a profound character, extending throughout the entire ore masses had not taken place, yet it must be conceded that wherever secondary agencies

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1 John Murray, LL.D., Ph.D., and Robert Irvine, F.C.S.,—'On the Manganese Nodules in Marine Deposits,' in the Transactions of the Royal Society of Edinburgh, vol. xxxvii. part iv, pp. 721—742.

2 Dr Penrose has treated this subject in detail in his report on 'Manganese,' pp. 564—569.

3 C. K. Leith on the "Iron Ores of Canada" in the 'Economic Geology,' vol. iii, No. 4, p. 281

have found suitable environment they have left unmistakeable evidence of their action There can also be little doubt that the deposits owe much of their present value to secondary enrichment which, if it had proceeded far over long continued periods in its intensified state, would have in all probability transformed these ore-bodies into some of the most magnificent ore-deposits in the world. But favourable conditions were wanting, and beyond mineralising the cavities, interstices, minor fissures and capillary spaces with rich manganese minerals crystallised in a remarkable state of purity, the rôle of secondary enrichment has not been of such a character as to indicate widespread alteration of the main masses of ore. However since it has played no insignificant part in increasing the economic importance of the ore-deposits, its claim to consideration cannot be overlooked. According to Emmons,[1] "Ore-deposits may be defined as concentrations of useful metals into bodies rich and large enough to be worked at a profit, but it is rare that the process of concentration has been single. In most cases they are the result of many and quite different processes, and the question is, which of these is the characteristic one by which it should be defined? The German geologists seem to consider that if sedimentation has 'any' part in the formation of the materials of a deposit it is, therefore, to be considered sedimentary." Emmons, on the other hand, is of opinion that the process that has brought it into its latest phase as a workable deposit is the one that should characterize it. But the conflicting point lies in the word "any" in Emmon's statement. In the author's opinion sedimentation has not played "any"

[1] Contributions to Economic Geology, 1904, p. 224.

but *the* part in the formation of the Sandur manganese-ore deposits, and secondary enrichment induced by metasomatic or similar processes has been an important factor in ore concentration. The Sandur deposits primarily owe their origin to sedimentary deposition from magmatic solution. Their economic value has been enhanced by secondary enrichment.

(125) Conclusion.

The author has now to discharge the pleasant task of thanking those without whose encouragement and assistance the preparation and completion of this monograph, in the midst of arduous professional work, would not have been accomplished. To Dr. Lewis Leigh Fermor, he is under deep obligation for the interest he has evinced during the preparation of this paper. Grateful acknowledgments are due to Mr. David Hooper for the analysis of the manganiferous lichen and of a specimen of calcite and for the determination of the specific gravity of two specimens. Mr. I. H. Burkill has kindly identified the specimens of manganiferous lichen. To Dr. S. B. Ghosh, the writer is indebted for the examination of the spring water of Durgamma Kolla. Through the kindness of Mr. Charles Aubert it has been possible to include a number of excellent photographs of the Ramandrug deposits. Thanks are also due to Mr. Charles Jambon who has placed copies of some shipment analyses at the author's disposal. Finally, this opportunity is taken to thankfully acknowledge the assistance rendered by Dewan Bahadur T. Kothandarama Naidu, Dewan of the Sandur State, in fostering a new industry in the State for the introduction of which the author is responsible. With these expressions of grateful acknowledgment this account, of what are among the largest and most remarkable manganese-ore deposits in the world, is brought to a conclusion.

PLATES
AND
MAPS.

Photo by A. Ghose.]

View of the Remains of an Ancient Line of Defence built on Kammat Haruvu.

The detection of manganese-ore boulders in the wall led to the discovery of extensive manganese-ore deposits on the plateau.

Photo by A. Ghose.

Distant View of the Principal Cliff of Manganese-ore at Durgamma Kolla.

The entire cliff is composed of manganese-ore.
The height of the cliff is 47 feet.

Photo by A. Ghose.

Crest of the Great Manganese-ore Cliff of Durgamma Kolla.

The white spots seen on the outcrop consist of the manganiferous lichen which conspicuously covers the outcrop of ore in many of the Sandur deposits

Photo by A. Ghose.

View of a Portion of the Main Cliff of Karadi Badsala Kativi Deposit.

The cliff entirely consists of manganese-ore. Columnar cleavage of the layers of ore is visible in the right-hand upper portion of the photo.

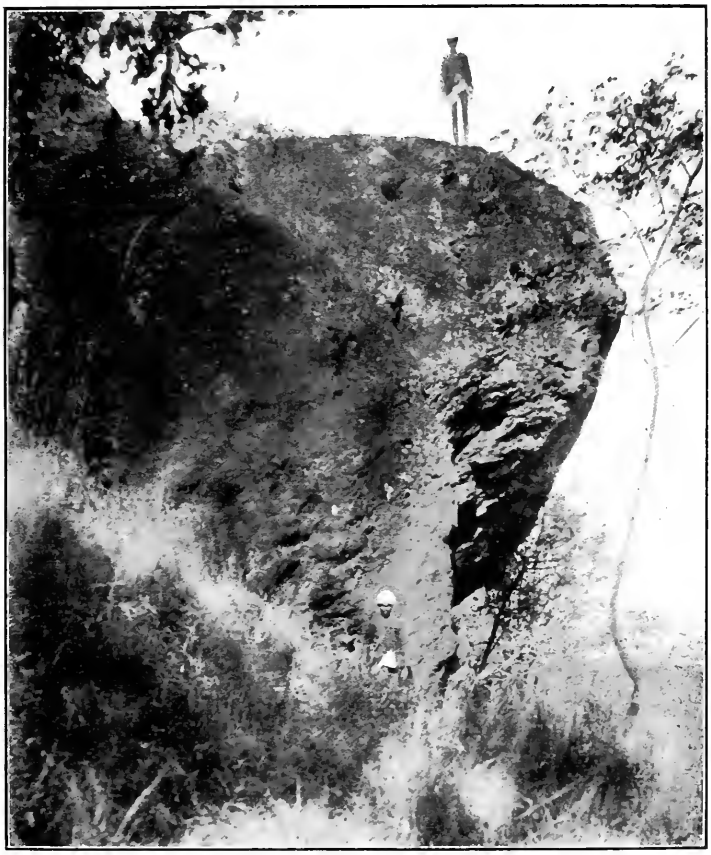

Photo by A. Ghose.]

.Photograph showing a Portion of the Great Outcrop of Manganese-ore at Girenath Kolla.

View of the Manganese-ore Outcrop known as Budhana Gundu in the Kanevihalli Range.

The protruding mass entirely consists of manganese ore

Transactions, Vol. IV, Pl. 9.

Photo by C. Aubert.]

View of the Ramandrug Hill showing the Main Workings and the Light Railway for the conveyance of the Ore.

Photo by C. Aubert.]

View of the Aerial Rope-way at Ramandrug.

This wire rope-way supported by seven trestles is of 2,600 feet span and conveys the ore from a height of 1,200 feet above the plain to the railway terminus at the foot of the range.

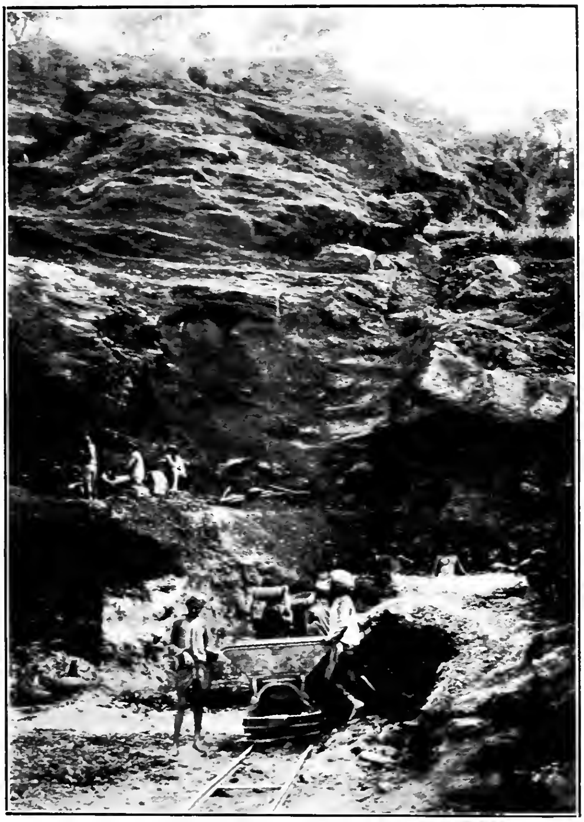

Photo by C. Aubert.]

View of a Portion of the Main Bed at Ramandrug.

The stratification and banded structure of the ore-body are seen to advantage.

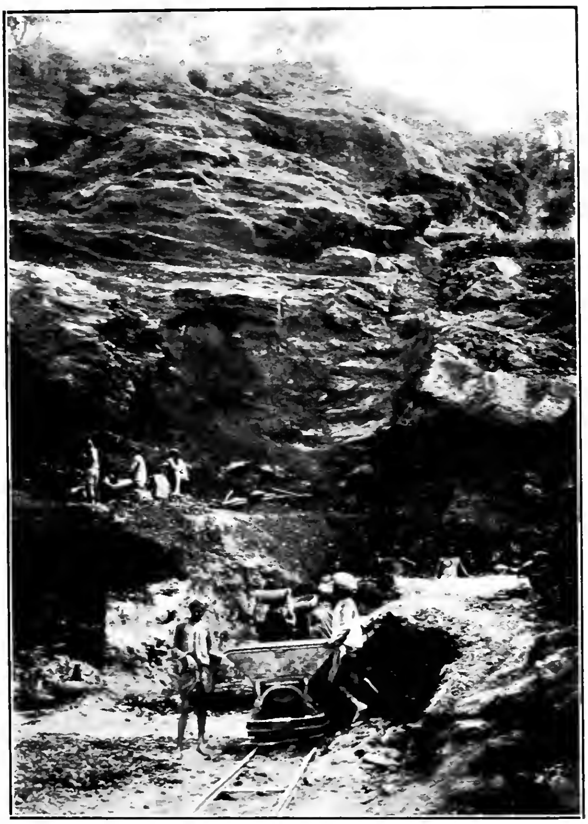

Photo by C. Aubert.]

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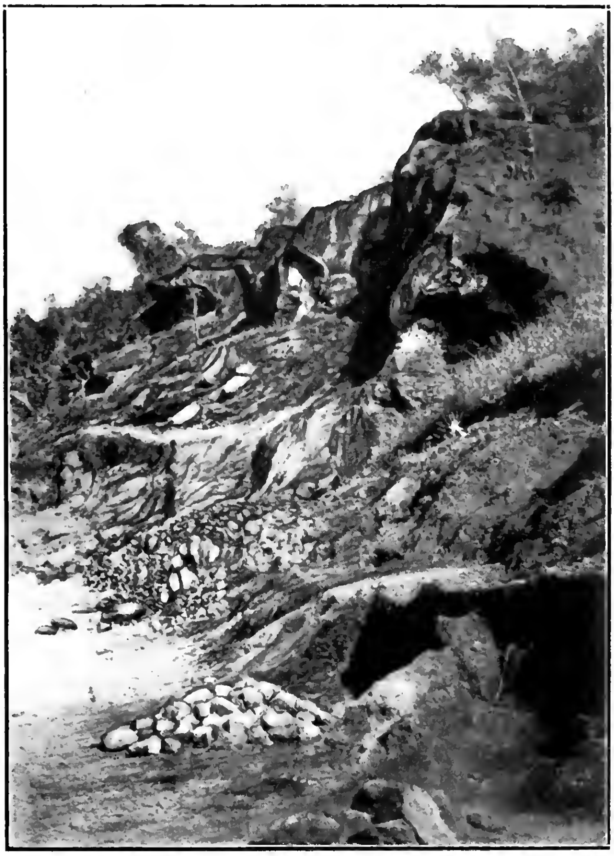


Photo by C. Aubert.]

End View of the Manganese Ore-bands of Ramandrug projecting in the Mavin Marad Kolla.

The protruding masses of manganese ore seen on the top of the photo, are portions of three distinct parallel bands of manganese ore which have been exposed by erosive action which carved out the ravine. The size of at least one outcrop will be apparent from comparison with the men working on the outcrop. Exposures of argillite and lithomarge are seen at the foot of the deposits.

Photo by C. Aubert.

Woddars at Work on the Sanna Sil Haruvu Deposit.

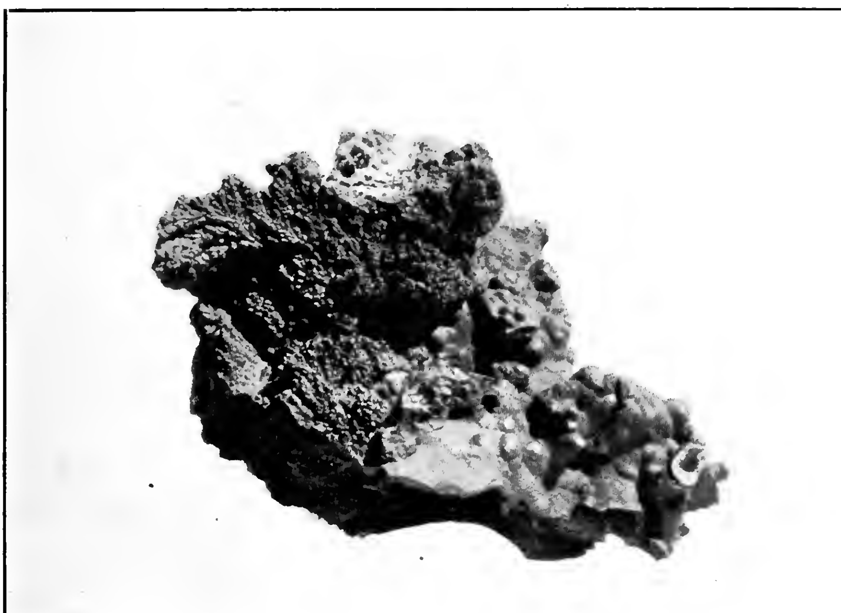
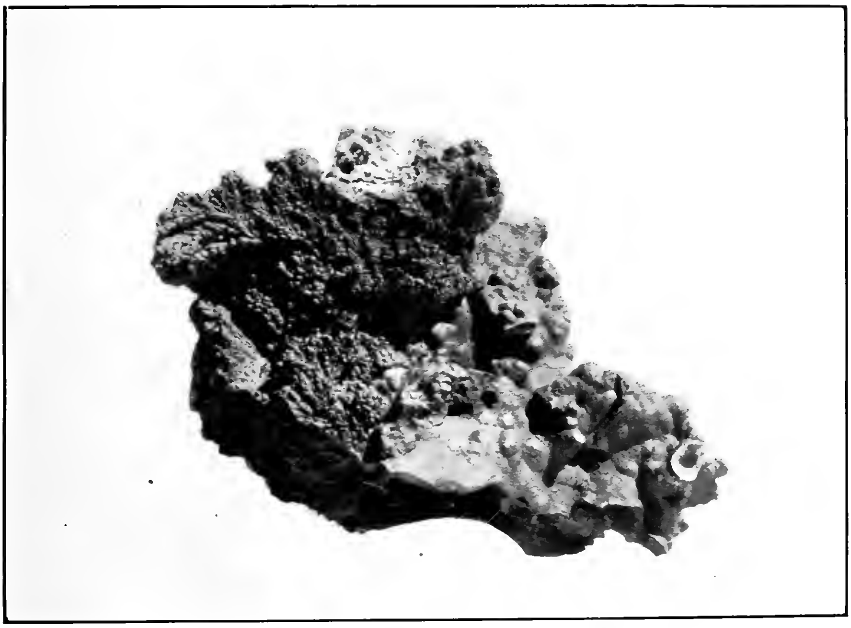


Photo by A. Ghose.

Stalactite of Psilomelane from Ganigithi Kolla Deposit showing fern-like arborescent structure.

The white efflorescence encrusting the top consists of allophane.



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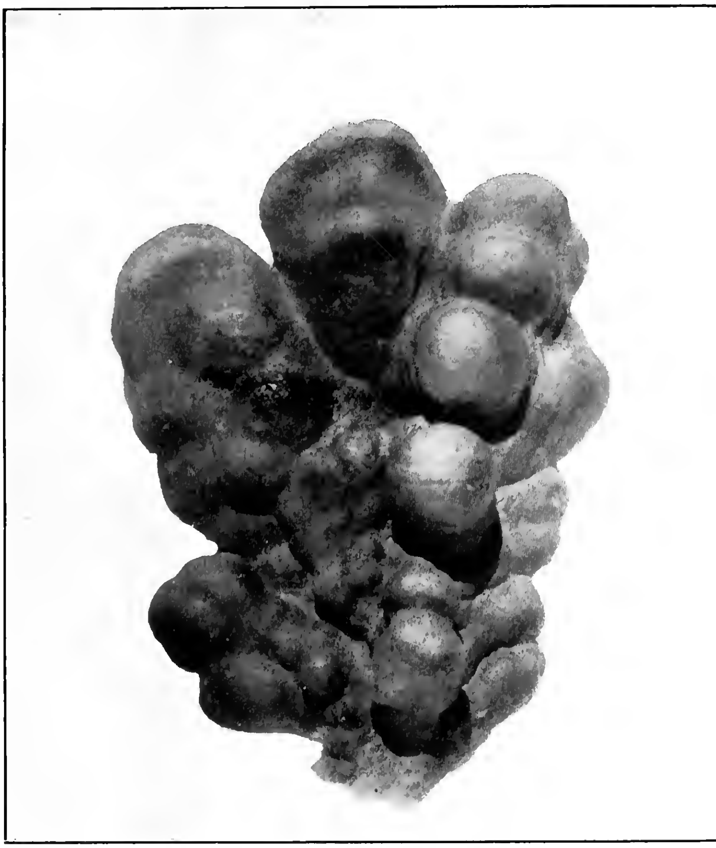


Photo by A. Ghose.

Photo of Manganiferous Concretion from the Subrayanhalli Neer Kolla Cliff Deposit.

Some of the concretionary aggregates show a tendency to bilateral disposition.

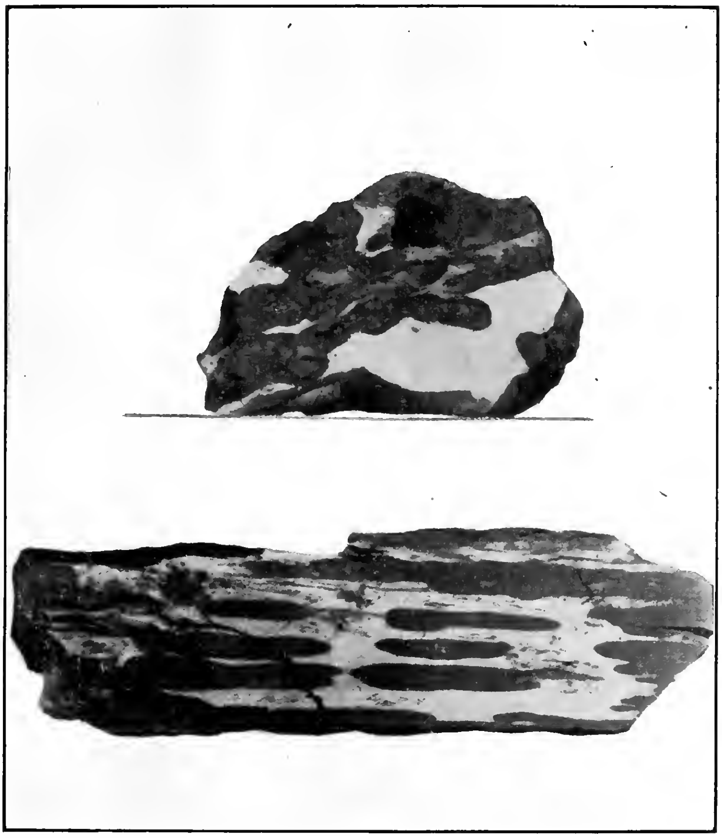


Photo by A. Ghose.]

The Specimen in the lower part of the photograph shows the Segregation of Manganese and Iron Ores into lenticular patches.

The phyllite has lost its schistosity to a marked extent and the ore does not occur in thin leaves which preserve their continuity. The specimen depicted in the upper part shows further stages of ore-segregation leading to the formation of concretions of manganese-ore and of limonite. The lighter portions consist of altered phyllite.

Photo by A. Ghose.]

Microphotograph of a Section of Oolitic Manganese-ore from Karadi Badsala Kativi.

Magnification : 45.

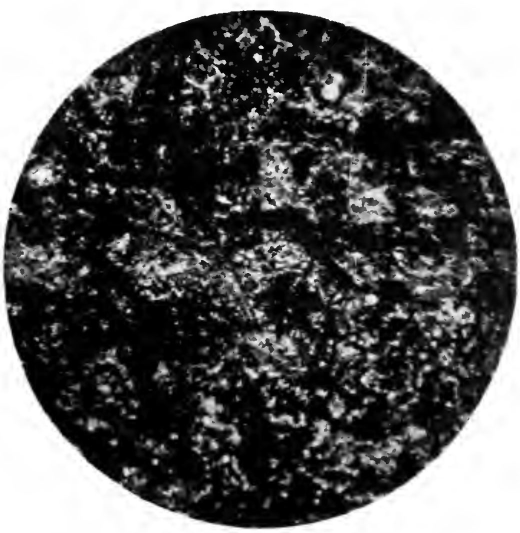


Photo by A. Ghose.]

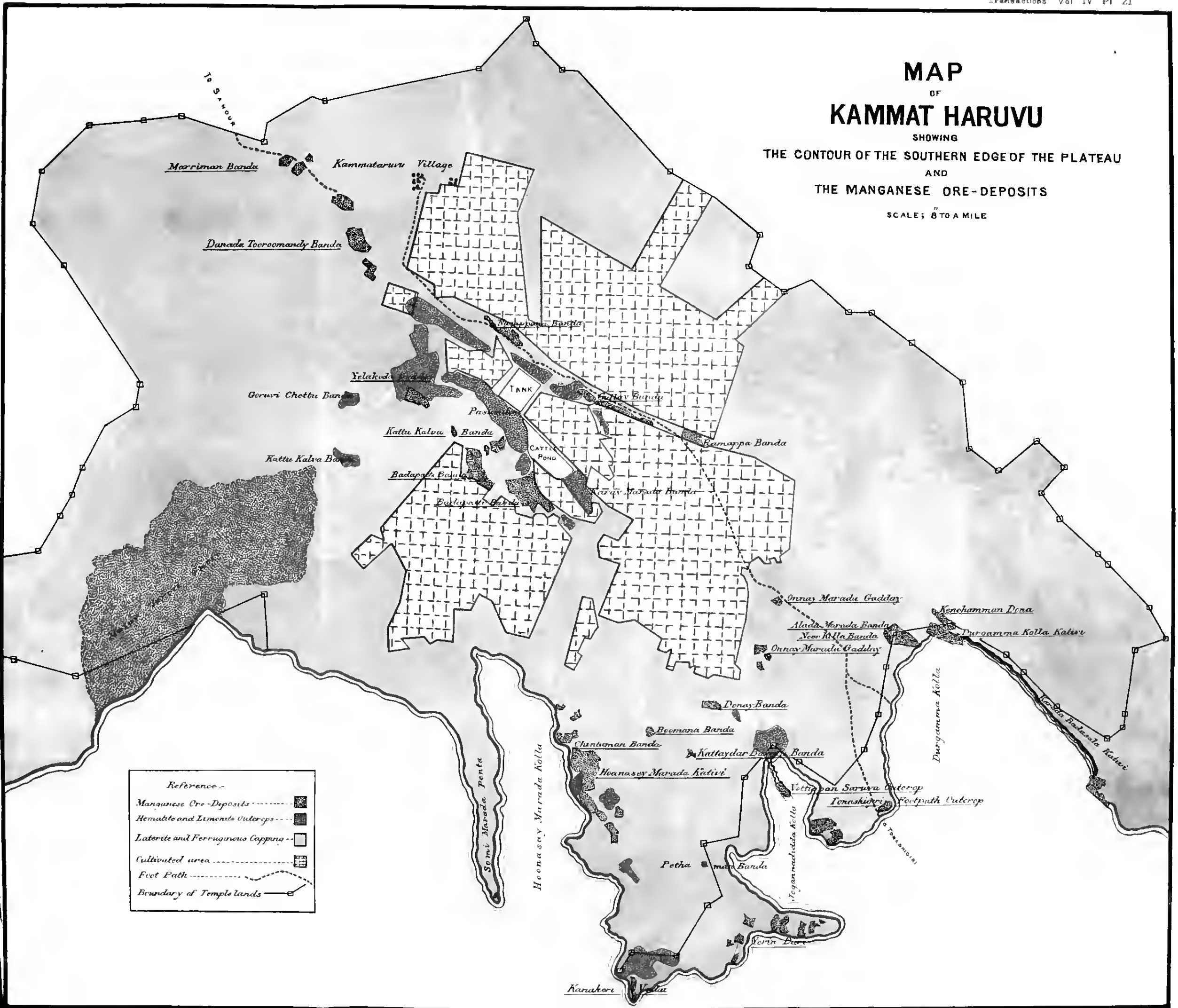
Microphotograph showing partial replacement of Phyllite and Segregation of Iron and Manganese Minerals into lenticular patches which ultimately form concretionary masses.

Magnification: 22.

A. Ghose. Manganese Ore-Deposits of the Sandur State

Transactions. Vol IV. Pl 20.

Topographic details mainly from the map of Madras Survey.


MAP
OF
KAMMAT HARUVU
SHOWING
THE CONTOUR OF THE SOUTHERN EDGE OF THE PLATEAU
AND
THE MANGANESE ORE-DEPOSITS
SCALE; 8" TO A MILE
To Sandur
Marriman Banda
Kammataruvu Village
Danada Tooroomandy Banda
TANK
CATTLE POND
Ramappa Banda
Onnay Marada Gadday
Kenchamman Dona
Durgamma Kolla Kativi
Donay Banda
Boomana Banda
Chintaman Banda
Hoanasey Marada Kativi
Somi Marada Penta
Hoonasey Marada Kolla
Durgamma Kolla
Footpath Outcrop
Petha
Reference.-
Manganese Ore-Deposits
Hematite and Limonite Outcrops
Laterite and Ferruginous Capping
Cultivated area
Foot Path
Boundary of Temple lands

Transactions

of the

Mining and Geological Institute of India.

Part 4.] 1910. [June.

Extraordinary General Meeting, Calcutta.

Wednesday, 30th June, 1909.

An extraordinary general meeting of the Institute, convened in accordance with Rule 39 (*a*) of the Rules of the Institute then in force, and duly notified in accordance with Rule 39 (*b*), was held at 27, Chowringhee, Calcutta, at 11 A.M., on Wednesday, June the 30th, 1909. The following members were present:—

Messrs. H. G. Graves, President (in the chair), G. de P. Cotter, L. L. Fermor, K. A. K. Hallowes, H. H. Hayden, Major F. C. Hughes, Messrs. G. E. Pilgrim, G. H. Tipper, and H. Walker.

The business before the meeting was the incorporation of the Institute under the Indian Companies Act (1882), under the title of "The Mining and Geological Institute of India" as a limited Company without the addition of the word "Limited," in accordance with the Resolution proposed by Mr. R. P. Ashton and seconded by Mr. F. J. Agabeg at the annual general meeting held on January the 31st, 1908 (Trans., Vol. III, p. 7), further referred to in the Report of the Council for 1908 (Trans., Vol. IV, p. 7). The following resolutions, suggested by the honorary solicitors, Messrs. Orr, Dignam & Co., were put before the meeting:—

(1)

That it is desirable that the Mining and Geological Institute of India should be registered under the Indian Companies Act, 1882, in pursuance of Part VII of such Act as a Company limited by guarantee and that the members of the said Institute assent to its being so registered.

(2)

That it be and is hereby declared that each member undertakes to contribute to the assets of the Company, in the event of the same being wound up during the time that he is a member or within one year afterwards for payment of the debts and liabilities of the Company contracted before the time at which he ceases to be a member and of the costs and expenses of winding up the Company and for the adjustment of the rights of the contributories among themselves, such amount as may be required not exceeding (as the contribution of each member) the sum of five rupees.

(3)

That the draft in print (identified by the signature thereon of the Chairman) of the intended Memorandum of Association and Articles of Association of the Company and now submitted to this meeting be and the same are hereby respectively approved and adopted as the Memorandum and Articles or Regulations of the Company with power nevertheless for the Council, before the same be filed with the Registrar of the Joint Stock Companies under the said Act, to make or assent to such variations or modifications thereof as they may think fit for the purpose of complying with any conditions imposed or to be imposed by the Local Government with a view to the Company being registered with liability limited by guarantee but without the addition of the word "Limited" to its name in accordance with the provisions of section 26 of the Indian Companies Act, 1882, to the intent

(1) that all the members of or subscribers to the said Mining and Geological Institute of India as now constituted shall be and become members of the Company;

(2) that the Memorandum and Articles as and when so filed shall be and become the Regulations of the Company and be

binding on as well all the members of and subscribers to the Mining and Geological Institute of India as on all the members present and future of the Company; and

(3) that as from the date aforesaid all such members or subscribers shall become liable and shall pay to the Company all subscriptions and other monies which under the existing Regulations of the Mining and Geological Institute of India or under the Regulations for the time being of the Company are or may become due in respect of subscriptions or otherwise.

(4)

That the Council be and are hereby authorised and required to do all such acts and things as they may think fit for the purpose of carrying out and giving effect to the foregoing Resolutions.

Each Resolution was put separately before the meeting and was adopted unanimously.

The meeting was then declared closed.

NOTE:—The incorporation was completed with the registration of the Institute on the 16th day of September, 1909. Copies of the Memorandum and Articles of Association were issued to the members on the 22nd of December, 1909.

Meeting at Asansol.

Monday, the 23rd August, 1909.

An ordinary general meeting of the Institute was held at Chota Nagpur Mounted Rifles Club at Asansol on Monday, the 23rd of August, 1909, at 2-30 P.M. As neither President, Vice-President, nor any other member of the Council was present before 2-45 P.M., Sir Thomas Holland was voted into the chair. The minutes of the last meeting were read and confirmed.

The papers read at the general meeting at Jherria on July the 13th, 1908, and published in part 2, Vol. III, of the "Transactions" were down for discussion, but, as no one had any remarks to make, the Chairman called on Mr. W. J. Greener to read the following paper :—

Coal Cutting by Machinery.

BY

W. J. Greener.

In the following brief notes I intend to deal with the various machines used for under, over, or side cutting coal, but I shall only describe the machines with the working of which I have had personal experience.

LONGWALL MACHINES.

The machines may be divided into three classes or types :—

(1) The disc machine as the Gillott and Copley, the Diamond, etc.

(2) The chain machine as the Morgan Gardiner and Austin Hopkinson's.

(3) The bar machine as Hurd's bar machine.

These are all longwall machines and are useless in pillar and stall workings. I will deal with them first, as they are much the most important type.

THE DIAMOND MACHINE.

The disc is the oldest form of longwall machine and has up to the present time probably given better results than any other type. The diamond is the last of the disc machines and is in my opinion the best, as they have not only gained by the experience of other makers, but have the advantage of having worked their own mines at

Normanton for some years past with their machines. The disc is usually made in halves and the picks fit into boxes (10 boxes and 3 picks in each) which are attached to the periphery of the disc. The wheel or disc can be made for undercutting or overcutting from 3′—6″ to 7′—0″ in depth. The motive power is either electricity or compressed air. The advantages of the diamond machine are strength in construction, and with plenty of power it will cut in very hard substance. The picks are quickly changed and easily sharpened. The only disadvantages it possesses are—

Firstly.—In cutting in tender seams there is a great tendency for the coal to settle on the cutting wheel causing either the temporary stoppage of the machine or else making a great deal of small coal; this is due to the distance apart the spraggs have to be set, as with a 6′—0″ wheel they cannot be closer to the coal than 7′—0″.

Secondly.—The machine will not cut itself in but has to have a stable made for it.

The compressed-air machine is usually made with two 10″ cylinders, the cutting wheel being fixed in the centre of them. Its length is about 10′—0″, width 3′—3″ and height on sledges about 1′—9″, weight two tons.

THE CHAIN MACHINE.

I have only had experience of the Morgan Gardiner machine working, but have examined very carefully Mr. Austin Hopkinson's machine. I must say I liked his ideas both in the engine part and also the chain which is very strongly made, but unfortunately he could not show me one working before I left England, so I shall say no more regarding this machine.

The Morgan Gardiner pleased me very much, but it is only suitable in very soft holing dirt. The difficulty being to make a chain strong enough. The advantages of this type of machine are, if it is essential to cut in the coal it only takes about 3″ instead of 5″ or 6″ with a disc or bar; also it is easier to keep the coal up as spraggs can be set within 3′—0″ of the coal; this is important in tender seams. It is a quick cutting machine, will cut itself in and clears its own holing fairly well. The principle of the chain machine is ideal, but it has never been very satisfactory up to the present time. This was the first machine I saw running on sledges. We afterwards adopted the idea to all our machines with the best possible results.

THE BAR MACHINE.

This is Hurd's patent and is made by Mavor Coulson & Co., Glasgow, and is now called the Pick Quick. It is no doubt a machine with a big future before it if one or two minor difficulties can be overcome. These are:—

Firstly.—The expense of new picks which run about 6*d.* each.

Secondly.—A good method of fastening the picks into the bar so that they are not lost in cutting and can easily be taken out when required.

Thirdly.—The great weight of their No. 3 machine for compressed air, of which I am now speaking.

Fourthly.—The first cost of this machine is also heavy.

The advantages are quick cutting: it is the quickest cutting machine in hard holing I have seen, and as the bar which is either parallel or taper (I prefer the parallel) is only 7″ in diameter, the spraggs can be set close up to the coal. The machine cuts itself in and out, so does not require any stable holes. The bar can be fitted for over or undercutting, and also by means of screws it can be lowered or raised about 7″. It has also to-and-fro motion of 2 or 3 inches; this prevents the bar from clogging and sticking in the holing. The bar is made with a spiral thread which brings a portion of the holing dirt out, but a man is necessary to rake out after the machine. There is also a clever device on this machine for regulating the speed of travel.

We next come to the heading machines of which there are three different types:—

(1) Percussive.
(2) Chain Machines.
(3) Rotary Machines.

I shall only deal with the first-named type, as they are in all probability the leading machines of the future, and are much more popular in England at the present day than either of the other two types, which are heavy and cumbersome though they will do good work when once set.

There are several percussive machines on the market, but I shall only take the Siskol (an improved form of the Champion Machine), the Patterson and the Little Hardy.

THE SISKOL.

The percussive machine is attached to a column wedged tightly between the roof and floor and by means of a worm geared into a toothed segment sliding on the column, the machine is worked in either a vertical or horizontal direction. The forward motion is regulated by a screw 2′—0″ in length at the back of the machine worked by a handle. (This handle is held in the left hand). The setting and flitting of this machine from one stall to another occupies half-an-hour, and the machine will hole 5 headings 12′ × 4′ in a shift of 9 hours, one man and a boy with the machine. The machine is flitted from place to place on a tram.

The chief advantages are strength in construction, and as it strikes a very strong blow (about 350 per minute) it will hole in very hard fire-clay and other substances. The cost of repairs to these machines are, however, heavy, and 6*d*. per ton must be allowed for stores and repairs in any estimate as to the cost of working.

It is the only machine of this type that will hole in any part of the seam. Size cylinders 6″, stroke 10″, weight about 500 lbs.

THE LITTLE HARDY.

This is the same type of machine as the Siskol. It is suitable for cutting stables for longwall machines, but is not capable of doing the same amount of work as the Siskol. It is, of course, a cheaper and lighter machine, but those are its only advantages over the Siskol.

Size 3″ cylinder, 6″ stroke (600 strokes per minute), weight 200 lbs.

THE PATTERSON MACHINE.

This is in my opinion the best of all heading machines. It consists of two cylinders 3½″ diameter, stroke 6″, placed side by side, and the pistons moving alternately act instead of valves, thus simplifying the working parts. Having two cutting rods working alternately causes the machine to keep up to the face; this saves any standpiece and the machine needs no setting, simply running on rails. The forward motion is produced by a rope passing round the frame and winding on to a drum at the back similar to a longwall machine. The horizontal motion is governed by two handles held in the operator's hands and similar to a pair of scissor handles. The advantages the machine possesses over all others are simplicity in construction, no working parts to get out of order. I know of one machine that was working for six months without a penny being spent in repairs. It requires no setting and can be used in narrow work or long wall. It is easily flitted and will cut in an 18″ seam. It will work with about 50 lbs. of air, but gives much better results with 70 lbs. or over. This machine can only be used for undercutting.

Having briefly described the various machines the following questions naturally present themselves:—

1. What are the advantages of coal cutters? The chief advantages in using coal cutters are:—

(*a*) Increased number of tons per shift.

(*b*) Increased output from a given length of face.

(*c*) By causing the face to move faster, thereby saving broken timber.

(*d*) The decreased cost in certain mines owing to the coal being too hard to hole by hand.

(*e*) In seams of 2′—0″ and under it is almost essential to use coal-cutters if you expect any round coal.

2. In what seams cannot they be profitably worked?

(*a*) If a mine can be worked by hand at Rs. 2 and under there is nothing to be gained by using machines.

(*b*) In very tender seams.

(*c*) In very thick seams (6′—0″ and over).

They give the most satisfactory results in mines 4′—6″ and under, especially in mines where the holing is very hard, or where a band of dirt is in the middle of the seam, and it is desirable to remove this without losing any of the coal. Mines with very bad roofs generally work better with machines, as the face advances quicker and does not give the roof time to break up.

3. How does the coal cut by machines compare with that cut by hand?

(1) As regards percentage or round and small.

(2) As regards cost.

(3) As regards output per man.

Of course all these items vary at different collieries where different seams occur and different systems are practised. But a rough idea may be obtained by the figures which were taken during 12 months at a colliery where machines and miners were working in the same seams, so a fair comparison was obtained.

(1) The round coal got by machines was 55 per cent. against 50 per cent. by hand.

(2) The average cost in these mines was 2*s.* 10*d.* by machine against 3*s.* 3*d.* by hand.

(3) Tons per man per shift 8·36 by machine.
,, ,, ,, 4·34 by hand.

All these tests were made in mines exceedingly difficult to work by hand.

With regard to coal-cutting in India I have seen very few seams suitable for longwall machines, and in mines where heading machines are being used, I think it is very doubtful if they are getting the coal as cheaply as by hand.

There may be some advantage to be gained in the quicker rate: a heading may be driven by machines, and where labour is scarce it may be policy to use them (but remember the coal has still got to be filled out by hand and, unless this can be done immediately the places are cut, you will soon have your machines lying idle). My own opinion is, where you can, do without coal-cutters, and where they are imperative be quite sure you get the right machine for the particular seam you wish to work, and then it will need all the time and attention you and everybody else concerned can possibly spare to make it a success.

Lastly, what is the best motive power?

Electricity is undoubtedly the cheapest power to use, but it is better to keep it out of any gaseous mines ; also none of the heading machines (with the exception of the Jeffrey heading machine) can be driven by electricity, and as these are probably the machines most likely to be used in this country, air seems to be the most suitable motive power.

In selecting your plant be sure and have it big enough, and the higher the air pressure the more useful work will the coal-cutter give. Have your air-pipes big enough and plenty of receivers to take out any water that is made in them.

Of course, small air compressors may be worked electrically near the working face, but I have no figures to show if this system is as cheap as compressors on the surface.

APPENDIX.[1]

Statement shewing the number of the various types of Coal-cutting machines at work during the year 1908 *in the British Isles, also giving the motive power and number of tons produced.*

Description of Machines.	Number driven by		Statute tons of coal cut.		TOTAL.
	Electricity.	Compressed Air.	Electricity.	Compressed Air.	
Disc	409	418	..	..	..
Bar	230	31	..	..	..
Chain	89	5	..	..	..
Percussive	2	449	..	..	..
Rotary Heading ..	7	19	..	..	..
GRAND TOTAL ..	737	922	7.467,839	5.941.071	13,408,910

Approximate statement shewing tons produced per one machine of each of the various types during the same year 1908.

Type.	Electricity.	Compressed Air.
Disc	11,339	10,419
Bar	10,090	12,583
Chain.. ..	6,100	5,953
Percussive ..	..	1,893
Rotary ..	2,896	1,347

[1] Submitted a week after the meeting.—Ed.

This table shews that the output from one long wall disc machine is about six times that from one pillar and stall percussive machine.

DISCUSSION.

Mr. Glen George, in opening the discussion on Mr. Greener's paper, said—that Mr. Greener had expressed a doubt as to the cost of coal-cutting by machine in India being cheaper than hand. As this financial aspect of the question was perhaps the most important of all, the speaker thought some actual figures and further estimates would be of interest to the members. Considering hand-cut coal first, the average costs might be put as follows:

		Rs.	As.	per ton
(1)	Paid to miner for cutting and loading ..	0	12	,, ,,
(2)	Royalty	0	4	,, ,,
(3)	Working (winding, hauling, etc.), supervision and general charges	1	0	,, ,,
(4)	Calcutta and sundry charges	0	4	,, ,,
	Total cost into wagons at pit head ..	2	4	

No. 1 and 2 do not vary with the output.

No. 3 and 4 are standing charges and do vary.

It had been objected to Mr. George that these costs were too high, in particular the first and the important one for comparison—the As. 12 per ton paid to the miner. When all sums paid to the miner were considered he did not think this too high. As regards the other cost, Jherria costs and those in shallow pits were no doubt less, but the average total cost was not much less than Rs. 2-4 per ton considering that this included royalty and Calcutta charges.

Mr. George went on to consider machine-cut coal. A company deciding on machine-cutting had, or probably would have in the future, three alternatives. It could instal a compressed air plant, an electrical plant working air-compressors at the face, or take electrical power from the proposed power distribution companies.

Compressed air, while suitable for small plants in shallow shafts where workings are never distant, was not economical for the case of deep shafts, with distant working faces. It was the latter case in which machine-cutting must make a show against hand-cutting. As he would show later, hand-cutting was at least cheaper. Shallow shafts and new workings were attractive to labour. So what followed must be understood to apply to the case of a large installation in a fairly deep shaft, which, he took it, was the problem before machine-cutting in India. In this case electrical air-compressors at the coal face were the best. In any case he assumed that the power cost one anna per unit; air-compressors could not supply it for less, and it was doubtful whether a separate electrical installation could.

We could consider a supposed installation of six little Hardy or Siskol machines, as the percussive drill type was undoubtedly the one suited to Indian conditions.

To supply power for these would require 260 H.P. electrical air-compressors. The cost of the six cutters and two compressors would be Rs. 24,000. The coal is undercut, holes drilled, the coal blasted down, broken up, cleared from the face, and loaded. In one instance the actual output per machine, driven by natives after two months' experience, was 12 tons per day per machine. The conditions were not favourable and the men were not sufficiently experienced, and the output per machine would undoubtedly have gone up to 20 tons per day eventually. Mr. George understood this figure was reached in another case. The difficulty as regards the output was not in the machines, but in getting away the coal fast enough after it had been under-cut, and calculations as to output based on the fact that the machine could under-cut so many feet per hour were useless. To be fair to machines, we would assume an output of 25 tons per machine per day. The costs then would be—

Men driving machine. ..	1 An. per ton.	These are actual figures.
Drilling holes and clearing coal..	3·7 As. ,, ,,	
Blasting	5·0 ,, ,, ,,	
Loading into tubs ..	3·3 ,, ,, ,,	
General establishment on coal-cutters, *i.e.*— 1 European at Rs. 250 per month 1 mistri at Rs. 50. Stores Rs. 70 Coolies Rs. 50.	2 As. per ton.	
Depreciation at 15% cost excluding power.	1·5 / 16·5 As. per ton.	

Taking then power charges, the speaker said that a drawback of the drill type of machine was the power it consumed. In practice each drill required 20 H.P. He assumed in an installation of six drills that five were working. If all worked at once they would take 100 H.P. He assumed the average demand to be 60 H.P. and that this was required for half the time, *i.e.*, for 12 hours out of the 24.

That is, the total demand for five machines per 24 hours was 720 H.P. hours or 540 units. The coal cut would be 125 tons and the power cost As. 4·3 per ton.

So adding this to the previous cost of As. 16·5 the cost of machine-cut coal into tubs underground would be Re. 1-5 per ton, against As. 12 per ton for hand-cut coal;

i.e., the machine coal costs As. 9 per ton more. It would be objected that the foregoing costs were too high. As regards the output per machine; while, under favourable circumstances, a higher figure might be reached, he did not think the average would exceed this. The labour at machine cost he gave was if anything too low.

Drilling holes and clearing coal = As. 3·7 per ton. This was arduous labour, and this figure for it was not high.

Blasting = As. 5 per ton.

This was very high. Owing to the coal being blasted in narrow galleries 12 feet wide, an excessive amount of explosive was required. Were the width of the galleries increased to 20 feet this cost would be reduced; while if the coal could be worked in "rooms" in the American fashion the whole aspect of the coal-cutting problem would be altered.

The high cost of timber and the inferior labour rendered this, he feared, at any rate very difficult.

The cost of loading into tubs (= As. 3·3 per ton) was as low as the labour could be got to take.

So, it must be concluded, he was afraid, that while machine-cut coal might not always be As. 9 per ton dearer than hand-cut coal, it would always be considerably dearer.

He would like to discuss further, whether, in bad times, machine-cut coal could be mined at a profit.

Adding standing charges and royalty (which we stated to be Re. 1-8 in all) to the cost into tubs of machine-cut coal, we obtained a cost into wagons of Rs. 2-13 per ton.

It was urged with reason, Mr. George said, that the increased output from a colliery from the machine cutters would lower the standing charges in proportion. Again, in this direction, results, he feared, would be disappointing.

The drilling of holes and clearing of coal from the face required a class of labour that might be coal-cutting, while to realise the full advantage, no labour should be used on machine coal that might be coal-cutting. Taking this labour and that employed in loading, he did not think that more than half the output from our assumed plant can be considered as a net increase in output. Assuming the colliery had an output of 9,000 tons per month before, and that the output from the machines was 3,000 tons, the output afterwards would be 10,500 tons. Assuming the standing charges to remain the same, their cost per ton would be lowered from Re. 1-4 to Re. 1-1. The cost of machine-cut coal into waggons would then be Rs. 2-10 per ton, which was perilously near the selling price of a large number of coals in bad markets.

He did not bring forward the above figures as a general argument against coal-cutting machines, but rather to emphasise the caution necessary before going in for them.

He thought it might fairly be stated that machine-cutting, should not be gone in for, except where it was impossible to get hand labour, or in seams whose selling price at the pit head was not likely to drop below Rs. 3 per ton for long periods.

Mr. Turnbull asked what was the maximum height of coal it would be possible to blow down after it had been under-cut. The author replied that it depended greatly on the nature of the coal, and practical tests were the only way of ascertaining such a fact; but he thought six feet was plenty to blow down at one time to get satisfactory results from the shots.

Mr. Stuart McMurtrie said he differed a little from the author, in one or two details, who stated that in seams of two feet and under it was almost essential to use coal-cutters if you expected any round coal. If the seam had underneath it a good holing dirt it was probable that even without coal-cutters a good round coal could be obtained. These circumstances occur in the South-Western counties of England where seams much under two feet thick are worked and whence very good house coal is produced for use in the cities of that district.

On the other hand Mr. Greener states that in very thick seams (of six feet and over) coal-cutters cannot be very profitably worked. Mr. McMurtrie said that although this remark might apply to the use of coal-cutters in the long-wall face it at all events was hardly correct for all circumstances. Even in thick seams it was often most desirable to drive headings quickly to open out faces both in pillar and stall and longwall, and particularly in the case of long-wall work under a roof so bad, that the roads must be driven out first and kept standing in coal, while afterwards the goaf is left behind and the face brought back towards the haulage road. In such a case Stanley's machines or Siskol cutters are extremely advantageous, particularly the former which, by means of its exhaust, will ventilate the headings. There is no direct pecuniary advantage, but a very large pecuniary advantage is obtained indirectly on account of the quicker development. Even if thick seam longwall work be carried outwards, with roads maintained in the goaf, the machine, which in this case should be percussive, renders quick development possible where otherwise it might be slow.

In replying to Mr. McMurtrie, Mr. Greener said that his statement, that in mines of two feet and under it was necessary to use coal-cutters in order to get any round coal, referred to mines where it was necessary to hole in the coal. He understood from Mr. McMurtrie that in the seams he was referring to there was a fire clay in which all the holing was done. The author further pointed out that he stated in his paper that machines might be used in thick mines to drive main headings where speed was necessary, but that he did not think there was anything to be gained as far as reducing cost was concerned.

Mr. Heslop said he hoped that machines would be given a good trial in this country, as coal-cutting by machinery was only just in its infancy, and up to the present had not been given a fair chance.

Mr. Greener then read the following paper:—

The Watering of Roadways in Mines and the part Dust plays in an Explosion.

BY

W. J. Greener.

(With Plates 22—24.)

My original intention was to prove by the means of the accompanying plans and a paper to be read in England, not only the great expense colliery owners would be put to if a rule was brought into force making it compulsory for all mines which were dry and dusty to be watered, but also that instead of being a blessing, watering in a great many cases proved that the cure was worse than the disease, and the experiments to be described, I think, prove, this contention. The tests, drawings and plans were all made personally, and I am indebted to Mr. E. Douglas, the General Manager of the Pemberton Colliery Co., Wigan, for being allowed to publish them.

In bringing these notes now before the Mining and Geological Institute of India, I am a bit dubious as to how they will be received, as I am dealing with a subject that will probably not be general, in this country at least, for some years (I mean deep mining, *i.e.*, pits 1000 feet and upwards with high air velocities and rapid haulages). But the following extracts from Mr. Wilson's report of June, 1908, I think, justify me:

EXPLOSIONS OF FIRE DAMP.

"Happily India has so far escaped any great calamity from explosions of fire-damp, but during the year there were three accidents which resulted in the death of five persons.''

''As was pointed out last year, explosive gas is certain to be far more troublesome in the near future when the workings will have reached a greater depth from the surface, and no pains must be spared to make those, whose duty it is to examine the mine and safeguard the lives of the work-people, familiar with the properties of this subtle foe.''

''Some of the coals undoubtedly produce fine dust, and with the improved ventilating currents, and increased speed of the newer methods of haulage, this factor will have to be taken into consideration. In many mines with unworked pillars, the galleries cover a large area, and in these, away from the direct current of air, dust may steadily settle and await the time when some concussion caused either by a blown-out shot or slight explosion of fire-damp may arouse this latent power, and repeat the experiences which have been gathered at such a tremendous cost in older mining countries.''

From the above abstract you gather the views of the Chief Inspector of Mines for India.

My first experiment was made in the Orrell Five Feet Mine, and the accompanying plan shows a great deal more plainly than I can in writing what actually took place.

ORRELL FIVE FEET MINE.

The two headings were driven in solid coal at the same time about 30 yards apart, and were timbered in a similar manner, and from February 16th, 1907, till October 12th, 1907, about 7 months, one of the places was watered every twenty-four hours by means of a syringe with the results shown on plan. The watered place decreased in height from 4′—9″, to an average height of 3′—9″, and although no bars broke they were all very badly bent. The greatest effect of the watering was seen on the roof which was a strong metal, though the props being pointed sank into the floor, which was a warrant floor with a very strong rock, a few feet below. If the props had not been pointed there is no doubt the broken timber would have been considerable. In the unwatered place no appreciable difference can be noticed.

ARLEY YARD MINE.

The same test was made in this mine over a similar period, only in this case the roads were driven in the goaf. The sectional elevation in each case gives the best idea of the two places. In the watered place, which at the time this sketch was made was unsafe to travel, only nine bars were standing out of thirteen ; two of these were not supporting anything, the remainder had fallen out. The roof, a dark metal, had fallen practically the whole way to a height of two feet, but the floor had not lifted much. In the unwatered place there had been one small fall, and one or two props were showing signs of weight, otherwise the place was quite fit for travelling.

WIGAN NINE FEET MINE.

This is perhaps the worst example: in the watered place only three bars are standing out of seventeen, and the place is nearly made up with the roof falling, which is a grey metal: the floor has also lifted to a certain extent. The unwatered place shows no change at all.

Experiments were also made in the King Coal Orrell 4 and Wigan 4 Feet Mines, but these places got so bad, and eventually made up so solid where they were watered, that I was unable to take particulars of them; but they go to show the extreme danger of continuous watering in most of our English mines.

The next point to be considered is—what benefits, if any, do we get from this watering of roadways in mines? I think we may safely put it down that—

Firstly—The roads themselves do not improve with watering.

Secondly—The cost of timber is necessarily higher as water rots and breaks the timber.

Thirdly—The atmosphere of the mine is not improved by watering

Fourthly—The cost of working the mine is increased by the cost of the men employed in watering.

The only advantage claimed is safety in the event of an explosion. That is to say, certain people, and among them some of the best mining engineers of the day, state that if an explosion occurs and the roads all round the explosive zone are thoroughly watered, that explosion will be confined to the actual spot where it happened. With this view I do not quite agree, although I don't dispute that if a roadway is sufficiently watered it will have some check on an explosive current and may possibly stop it altogether; but what I do contend is that the amount of watering would have to be so excessive as to be detrimental to the roof and floor of the mine, and also the air would be so charged with humidity as to make it impossible for men to work in it. This applies more particularly to mines with a temperature of over 70° F.

The reports on the explosions at Cenwen Clydach Vale, Wingate Grange Universal, Udston and McLaren all seem to point to the fact that the explosion travels along the damp roads in preference to the dry. This was particularly the case at McLaren. These cases, I think, prove conclusively that mere watering will not stop an explosion. At Hampstead, where the air was saturated and about as bad for a man to work in as it could be, the air only carried 13 grains per cubic foot 3·7 per cent. Professor Dixin's experiments have shown that before you could get any safeguard you must have 5 per cent. of water vapour in the air, and if you want 5 per cent. of water vapour it can only be obtained by means of steam; further, that anything under 5 per cent. must be helping the explosive force.

Mr. W W. Turnicliffe, B.Sc., asked the other day for information on the following points, which are very important :—

1st.—The influence of varying amounts of dust.

2nd.—The necessary amount to carry on an explosion.

3rd.—The influence of impurities, such as stone dust, on the inflammability of coal dust.

4th.—The length of a dust-free space necessary to break the blast and localise it to the district of its origin.

My personal opinions are that—

1st.—Dust as dust is not explosive.

2nd.—It is a physical impossibility to moisten dust to the point of safety in high velocity currents.

From these two axioms I draw the following conclusions :—

1st.—Instead of watering roadways the dust must be removed.

2nd.—The slower the ventilating current is the safer in an explosion.

3rd.—A safety lamp of the very best type should be used in all mines where gas has or may be found.

4th.—No shots should be fired in any main airway or haulage road in any mine where gas has been found.

I think all these four suggestions are important, particularly the last one, as practically all explosions of recent years have been caused by shot-firing on an engine plane, and no explosive that I have seen yet is entirely free from flame.

Since writing the above paper the Royal Commission have published the Report on The Ventilation of Coal Mines, by Dr. Cadman and Mr. Whalley, and I give the following extract from their report which bears out my contention:

THE VENTILATION OF COAL MINES.

Dr. Cadman, D.Sc., F.G.S., on the Royal Commission of Mines, in his report under the heading "Temperature" says:—

The effect of temperature upon workmen was found to depend entirely upon the temperature recorded by the wet bulb thermometer, no matter what the dry bulb might register. At 72° F. wet bulb it was found that heavy clothing was removed and only light clothing worn. At 80° F. wet bulb, providing the maximum body surface was exposed, hard work was possible, the capacity for work being greatly increased if a current of air or breeze passes over the body. From 80° to 85° F. wet bulb, work seriously affected. Hard work almost impossible. In one or two cases it was noted that the effect of watering roadways to prevent coal dust explosions had been the means of increasing the wet bulb temperatures to the extent of affecting the labour capacity of the men employed in the vicinity.

Several cases were also recorded where natural secretions of water from faults, etc., caused an increase in the wet bulb temperature enough to seriously inconvenience the men employed. This inconvenience was not experienced by those employed in other parts of the same mine where the wet bulb temperature was not altered, the dry bulb temperature being almost uniform in both cases.

DISCUSSION.

Mr. J. R. R. Wilson said that, in his opinion, coal-dust was explosive without gas, and further, the quicker the ventilation, the safer. He quite agreed that watering roof, sides and floors was, in many cases, dangerous, and in some mines, with a warrant floor, impossible. He suggested watering the coal-dust by means of a spray, as the tubs travel along the engine road; and also that, as far as possible, the tubs should be made dust-proof, for the whole of the dust in haulage came from the tubs. With the other points of the paper he agreed.

Mr. Greener replied that by coal-dust as dust not being explosive, he meant that, without a little gas being present, coal-dust would not cause an explosion by means of a defective safety lamp, or spark from an electric motor; and if a blown-out shot would cause an explosion without gas, why wasn't there an explosion with every blown-out shot in a dry and dusty mine? He quite agreed that once an explosion was initiated, coal-dust would carry an explosion to any distance. The author's idea in advocating a slower ventilation (*n.b.*, not a less volume of air) was that, in the case where coal tubs were watered, a rapid ventilation would absorb the moisture faster than a slower ventilating current; also, the slower the ventilating current, the less dust would be carried in suspension.

Mr. G. F. Adams said he thought they were much indebted to Mr. Greener for bringing this important subject before them. It would, he thought, be a reflection on the Institute if they did not, at any rate at times, go, in their papers and discussions, beyond the immediate requirements and present conditions of Indian Mining. He could not agree with Mr. Greener's words "dust as dust is not explosive". If dust as dust was not explosive, what would they expect to happen, when an explosion, on its way to the pit, reached a dry and dusty intake? It would die away. What did happen? In every big explosion that he had had anything to do with, the story was the same. The intakes, where the dust was and where the oxygen was, were wrecked, leaving the returns comparatively free from signs of force or great heat.

Mr. Greener had said that an explosion travelled the damp roads in preference to the dry ones. He had heard this statement before, but he had never seen anything at any explosion to make him attach the slightest importance to the theory. There was certainly nothing at Universal to warrant him doing so. He did not go down Clydach Vale until some weeks after the explosion, but he could see that the usual course of events had there again taken place, intakes wrecked, returns comparatively untouched.

He would like to mention three facts, which he thought were pertinent:—

At the Albion explosion the only district saved was the one which had a wet intake.

After the Universal explosion he added together the total length of roadway in which signs of force or burning had been seen. The total was a little over seven miles. No accumulation of gas in any mine, he thought, could be alone responsible for such a blast.

After one of the big explosions in South Wales, Mr. J. Dyer Lewis, now the Inspector for the Swansea District, examined some of the coked coal-dust through a microscope, and found, he told him, in each particle of dust a small hole or rent, out of which the volatile matter in the particle had come, at the moment of explosion.

With regard to road watering, it had been a matter of daily routine in South Wales for twenty-five years. There the usual practice was to water the floor, more or less thoroughly, and the roof and sides slightly. Unfortunately the usefulness of the work was lessened owing to the great amount of dust which accumulated on the main haulage roads in South Wales, chiefly on account of the practice of loading the tubs considerably higher than the top of the tub itself, and he had noticed many times when thickly-lying dust was watered, in how very few hours the dust was quite dry again. Of course the answer was, 'remove it,' but, especially in a large mine with many miles of haulage road, it was a case where theoretical excellence came up against practical possibility. From time to time it was removed, and at any place from which it had been recently removed the better results obtained by watering were easily apparent.

He thought that the extra cost of watering would be very little in many mines compared with the extra cost which would be entailed by the total prohibition of shot-firing in any main road of a mine in which gas had been found, as suggested by Mr. Greener.

Professor Galloway, to whom the profession is so much indebted in connection with the dust theory, is of opinion that if the floor was kept continuously and thoroughly watered, no dust would accumulate on the roof and sides. He however had never seen a road, except a naturally wet one, where the continuity and thoroughness were sufficient to prevent such accumulation.

Mr. Stuart McMurtrie said he quite agreed with Mr. Greener that, since watering was well known to be deleterious to the clays and shales usually associated with coal seams, the attempts to prevent explosions by universal watering would in effect be worse than the danger of an explosion itself, by reason of the fact that the roof would become very bad. Approximately the percentage of fatal accidents from falls of roof is 52 per cent. of the total, while that from explosions is very much less, and if much watering in a mine were adopted it would greatly increase the former danger, already greater. As regards cost. The cost of keeping the roads in repair for a mine where roads were made wet, either by watering or increasing the humidity of the current, would be enormous, and the speaker cited his experience of a mine ventilated by two adits, and whose workings extended three or four miles long and three or four miles wide. Such extensive workings are usually ventilated by shafts, but if ventilated by adits the difficulty of getting a good ventilating current is extreme; and it was so in this case, so that the comparatively feeble current of air became very wet, and the effect on the roof was conspicuous by greatly increasing the danger and the repairing costs. Wherever the ventilation of a district became improved by a shortened air circuit, the improvement in road repairs and also safety was most marked. The whole workings suffered from the dampness caused by adit ventilation, and although there is no fear of such trouble in a thick seam near the outcrop, it is a fact worth considering by those who in future may be comparing the advantages of shafts *versus* adits, or motives for winning Indian coal at a time when the outcrop mineral has become exhausted.

Mr. Glen George said that he was afraid he could not agree with the inference Mr. Greener apparently would draw from the statement that in the great explosions named, the roads in which watering was done were traversed by the explosion, while the dry roads were not. Mr. Greener seemed to suggest that water does more harm than good in regard to rendering coal-dust innocuous. In fact, in a discussion in an English Institute, one speaker recently made the statement, as an inference from the same explosions named by Mr. Greener, that water rendered coal-dust *more* explosive!

The question could be made clearer by an analogy.

Imagine a large store with a number of casks, some empty, some full of gunpowder, which however had been partially damped.

A shower of sparks is blown into the store falling among the casks. A large number of the casks containing the partially damped gunpowder explode, while the empty casks do not explode. Were we to infer from this that damping gunpowder makes it more explosive?

In the same way the dry roads were not damped because they contained no coal-dust, and the explosions did not traverse them, not because they were dry, but because they contained no coal-dust.

The statement that watering does no good, but probably harm, is totally opposed to South Wales experience Mr. Greener, he had no doubt, would modify his statement 'coal-dust as coal-dust is not explosive' into "coal-dust cannot be *exploded* except under abnormal conditions, such as the presence of small percentages of fire damp, high temperatures such as due to blown-out shots, etc."

With this he (Mr. George) would agree, as he did not think that the view urged, that a mere flame can explode coal-dust, was correct.

The instances adduced in favour of this are always a flame in a still atmosphere containing a combustible dust.

Such explosions occur in coal-hoppers, the holds of ships, the settling rooms of flour-mills, and are more properly combustions than explosions.

The line between an explosion and a combustion is not easy to draw. A good distinction was that recently suggested in the Engineering and Mining Journal, New York.

The writer there defined an explosion as when the kinetic effect or the force was manifested before the heat effects; a combustion when the heat effect is the prior manifestation.

The important point is that the conditions for these "rapid combustions"—not explosions—do not occur in a coal-mine.

They require a strong flame in a still atmosphere heavily laden with coal-dust. In support of this the speaker adduced the fact that in South Wales steam-coal mines, where, unfortunately, the most severe dust explosions have occurred, it is the custom to have large open lights at the pit bottom and on the screens, which are always in clouds of coal-dust.

The air currents are however always strong there, and reduce the temperature immediately around the flame. Mr. George knew of no instance in South Wales where this practice had led to an ignition of the coal-dust.

While the subject of Mr. Greener's paper was of intense interest, Mr. George did not regard it as "practical politics" as far as India was concerned. As had been stated that afternoon, the causes of the coal-dust danger in England were:—

(*a*) Tender and friable coals.

(*b*) Rapid haulages, shaking the coal and producing dust.

(*c*) Rapid ventilating currents, sifting and winnowing the dust.

In India our coal is not friable, our haulages are slow—five miles an hour is the maximum—and the less said about our ventilating currents the better.

Again, if the danger of coal-dust explosions did exist in India, our only remedy was to remove the dust, and prevent accumulations underground. This should always be done in India, from a far more imperative reason—the danger of spontaneous combustion.

Mr. Turnbull asked the depth of the mines in which the experiments with watering were carried out. The author replied :—

Orrell Five-feet Mine	..	560 yards.
Arley Yard Mine	..	500 ,,
Wigan Nine-feet Mine	..	330 ,,

Sir T. H. Holland anticipated a lively discussion, as the general trend of recent conclusions was in a direction different to that of Mr. Greener's paper; and some of the experts present are among those who hold strong views regarding the danger of dust. There can be no doubt that dust, even without inflammable gas, is explosive; the ancient way of producing "thunder and lightning" in theatres depended on the ignition of lycopodium dust, while explosions in flour mills must also be due to dust without gas. There appears to be a certain amount of logical confusion in the paper: it seems wrong to designate as "axioms" two statements of opinion, about one of which there certainly is much weight of opinion for an entirely different conclusion. It may be true that the watering of roadways causes certain damage, but it does not necessarily follow that dry roads are without danger: it may still be possible—many will say certain—that dust is as dangerous as gas, and if watering be ineffective or harmful, some other cure must be looked for. The main point for discussion appears to be whether inflammable dust *without* free gas is explosive; and, if so, whether there is a practicable cure: on these questions we may expect an interesting discussion.

Other members wanted to know if any hygrometrical tests have been made in Indian mines. The reply was in the negative.

Mr. G. F. Adams subsequently wrote and said that it would appear from Mr. Greener's reply to the discussion that he did not intend his words "dust as dust is not explosive '' to be taken literally. What Mr. Greener's contention appeared to have been was that dust as dust would not initiate an explosion under normal conditions. He thought that if by normal conditions Mr. Greener meant a dry and dusty place with dust suspended in the air, dust would initiate an explosion. He thought the recent experiments in England and on the Continent fully proved this. What was perhaps still a matter of doubt was, could an explosion be initiated with no coal-dust suspended in the air, but merely lying on the floor, with dry sides and roof. He thought that it might be possible if a blown-out shot struck the floor at an acute angle. If this could be proved by present-day experiments, the evidence against coal-dust as an explosive agent in mines would be complete. But even if it could not, and leaving out the question of the initiation of an explosion by coal-dust, the fact, now generally admitted, that a small ignition of gas could, by the agency of the coal-dust, if only lying on the floor, develop into a big and devastating explosion, should be sufficient to make the Manager of a dry and dusty mine leave nothing undone to render the dust innocuous. He once investigated a case where a small quantity of gas ignited at a naked light in a short longwall stall (level). The man and boy in the stall were slightly singed. They said afterwards that it passed over their heads out into the heading (rise). The heading was dry, and there was a small amount of dust lying in it, but there was no great accumulation of dust. As soon as the flame got into the heading, it increased in violence. It went down the heading—the men on the level below said they heard a roar—it tore a brattice sheet from the nails which held it and hurled it some feet away, and entered the level. The level was thoroughly wet (naturally), and on reaching it the explosion at once died away. He came to the conclusion at the time that if anyone had been in the heading he would have been killed, and that if the level to the pit had been dry and dusty this small ignition of gas would have caused another of the great explosions, which have occurred from time to time, and which have involved loss of life on so large a scale.

The following written contribution to this discussion was submitted by Mr. W. H. Pickering in December 1909:—I have read Mr. Greener's paper with very great interest. He has introduced a subject which is worthy of a prolonged discussion. His observation upon the effect of watering roadways are most valuable, for he places on record what actually occurred in a mine. Such practical experiments are too seldom made and recorded. It must be remembered, however, that in England coal seams are usually sandwiched between fire-clays and shales. Such strata swell and disintegrate when watered. A few of the Indian mines are not unlike the English mines, but for the most part the coal seams in India lie between strong sandstones which do not disintegrate when watered.

Mr. Greener has not pointed out another objection to watering in Indian mines. Ankylostomiasis is endemic in most parts of India. A damp hot mine (or moist atmosphere) is an ideal place for the propagation of a parasite which causes this disease. Experience in Europe shows that to stop the evil in an infected mine most drastic personal discipline is required—discipline of a character quite impossible in India. For this and other sanitary reasons it is desirable that Indian mines should be well ventilated and kept dry.

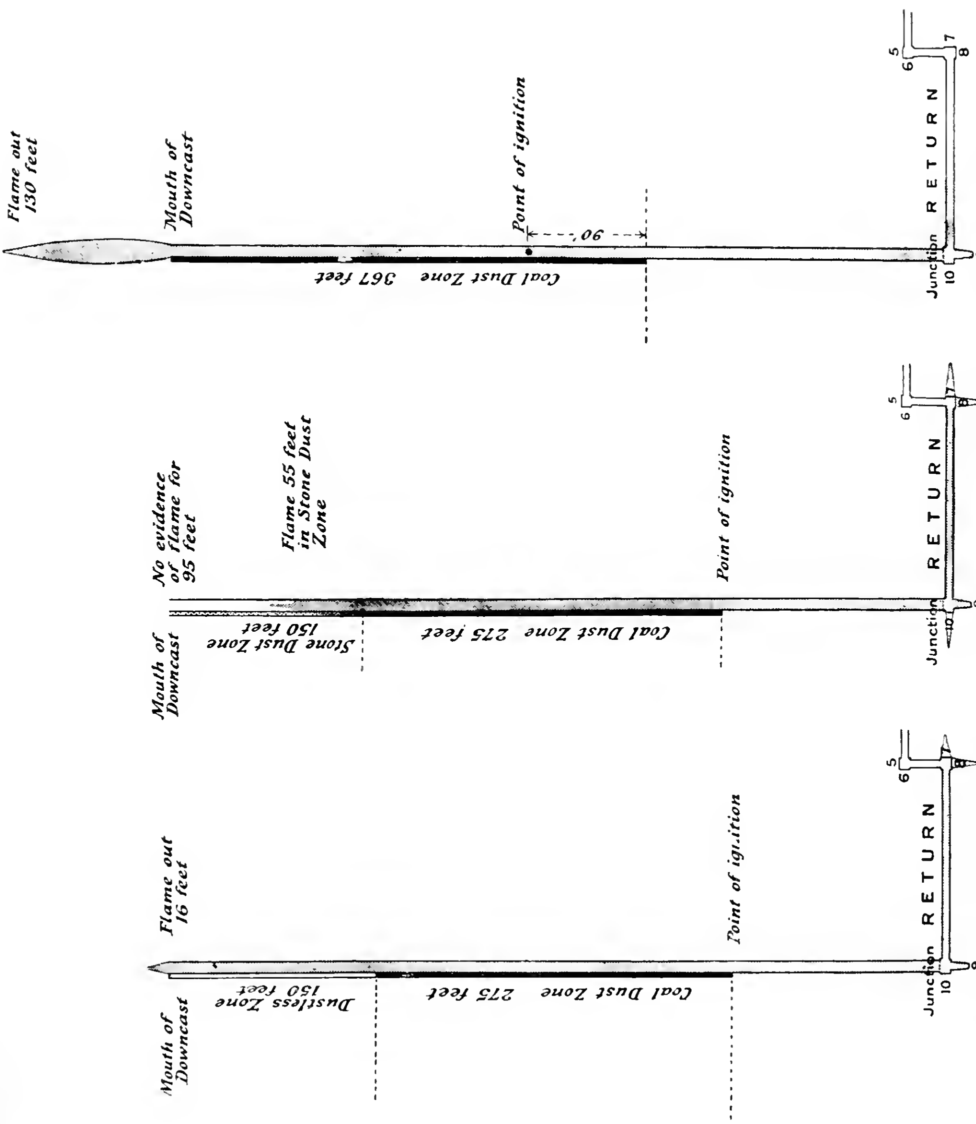
Mr. Greener's opinion "dust as dust is not explosive" is not an "axiom" at all, as it can easily be punctured with facts. For at least a generation it has been recognised that many dusts, including coal-dust, will explode in certain conditions. There has been some cleavage of scientific opinion on the matter, and the large majority of practical mining engineers, until recently, scouted the view that a serious colliery explosion could be caused by dust without the presence of fire-damp. No reasonable man can now remain a doubter in the face of the overwhelming published evidence. In the Second Report of the Royal Commission on Mines, dated July 1909, the following passage occurs on pages 82 and 83:—

"As we stated in our interim Report, the question "whether it is desirable to make compulsory the watering "of the roads in dry and dusty mines involved the con- "sideration of the wider problems of preventing the "accumulation of dust in coal mines, or of removing it or "dealing with it by various methods other than water. "We devoted considerable time to ascertaining the views "of inspectors of mines, colliery managers, and other "mining engineers on these important questions, and this "evidence, which has already been published, forms a "valuable commentary on the difficulties which surround "the subject. The witnesses, who included those best "qualified from scientific or practical experience to speak "on the question, expressed opinions which were often "widely divergent, as to the best means of meeting the "danger of explosions, but they were generally agreed on "two points—that coal-dust is liable to explosion with or "without the presence of fire-damp, under conditions "which at present are to be found in most coal mines in "this country and abroad, and that there is a pressing "need for the elucidation of the problems involved, by "a series of exhaustive experiments on an adequate scale. "With regard to the first point, it was a matter of satis-"faction to us that all the witnesses whom we consulted "expressed themselvs as adherents to the received opinion "on the subject of coal-dust. In this respect we found "ourselves in a better position than the Commissions which "preceded us—the Royal Commission on Accidents "in Mines (1879-1886) and the Royal Commission on Coal-"dust (1891-4)—in that we were able to confine our atten-"tion to the means of dealing with coal-dust without "having to prove the necessity of such means. The "battle between the *poussieristes* and the *non-poussieristes*, "to use a convenient French phrase, which has been "waged over half a century, has come to an end."

The experiments made at Altofts in Yorkshire, under the able directions of Mr. W. E. Garforth on behalf of the Mining Association of Great Britain, have proved that in a gallery as large as the galleries of a mine, most violent explosions can be produced by coal-dust alone. Pressures of 113 lbs. per square inch with velocities of 1,400 feet per second have been registered, heavy pit tubs and timbers have been hurled hundreds of feet and flames 180 feet long have been projected from the mouth of the gallery. It is understood that Mr. Garforth is preparing a full report of the experiments up to date, but a summary of what has already been done appeared in the *Colliery Guardian* of 30th July, 1909. Mr. Garforth has obtained a violent explosion with coal-dust from Natal. This should remove any doubt as to the explosive properties of Indian coal-dust, for Indian and Natal coals are near relations. Sir Thos. Holland in his "Sketch of the Mineral Resources of India" writes:—"The Gondwana Beds were laid down "in great river valleys on a continent, which, at the time, "probably stretched from India to Central and South "Africa, where similar coal-bearing beds of corresponding "age occur." The grave danger of dust explosions in Indian coal mines is perhaps nearer than is supposed. It is certain that the best seams will be followed to the dip, and that many of the inferior seams will be no longer worked when the out-crops are exhausted, and the heavy expenditure of sinking and equipping, winding and pumping shafts has to be faced. Thus, a rapid extension of deep mining in India may be expected at no distant date, and the mines will be dry and dusty. If watering is impracticable or undesirable, how shall the danger of dust explosions be scotched? Fortunately, Mr. W. E. Garforth has discovered a remedy which could be very easily applied in Indian mines. Only the very fine coal-dust is dangerous, and this can be diluted and rendered harmless by the application of fine stone-dust. It had been found that an explosion of the violence described above, will not penetrate far into a stone-dust zone. On the 7th and 8th October, by the kind investigation of Mr. Garforth, the Anglo-Indian Mining Engineers in England were invited to witness experiments at Altofts. On the 7th the dust was fired at night, the length of the coal-dust zone being 375 feet with a stone-dust zone of 100 feet between it and the intake end of the gallery. The explosion was very violent, but no flame issued from the mouth of the gallery. On the previous day, after a similar experiment, the tell-tale gun-cotton showed that the flame had only extended 21 feet into the stone-dust zone. On the 8th October, coal dust was fired without stone dust. Flame projected from the mouth of the gallery, but the explosion was not striking as in previous experiments, the reasons being that the mine timbers and other obstructions had not been fixed, and there had been no time to properly clear the tube of the stone-dust left by the previous experiment. It was as though a gun were fired without wadding and with impure powder.

The visitors were taken underground and shown the practical application of the stone-dust in the mine. The stone-dust is simply thrown by hand on the coal-dust, which it removes and dilutes most effectively. The cost is only one anna a running yard of a large gallery with expensive English labour. In this work an Indian coolie would be quite as effective as an English miner, who gets ten times the wage, so the cost of the stone-dust remedy in India would be very trifling. Indian mining engineers, therefore, should be very grateful to Mr. Garforth for having given them an opportunity of seeing the experiments. Though only a few Anglo-Indians were able to avail themselves of the privilege, they will be apostles, and the invitation has been the means of bringing the matter directly under the notice of the members of this Institute. They should not fail to read carefully Mr. Garforth's report when published, and to follow the records of the experiments which will be continued next spring.

By the courtesy of Mr. Garforth and of the Editor of the *Colliery Guardian* the following diagrams are reproduced:—



Length of Main Intake, 600 ft.: sectional area, 41 sq. ft. Length of return 295 ft.; sectional area, 28 sq. ft.
Numbers indicate position of safety valves.

View at downcast end of large sheet of flame issuing from mouth of gallery to a distance of 180 ft. Length of coaldust zone 367 ft.

View of Interior of Gallery.

The next item on the agenda was Mr. A. Ghose's paper on the Manganese-ore Deposits of the Sandur State. The printed abstract was read by Mr. L. L. Fermor, who then proceeded to refer to certain parts of the paper in greater detail.[1]

MR. GHOSE'S PAPER ON THE MANGANESE-ORE DEPOSITS OF SANDUR STATE.

Mr. Fermor said that the short notice read was an abstract of a very detailed and able account of the Sandur manganese-ore deposits, presented as a well-illustrated paper that the Institute should be proud to receive.

Mr. Ghose first became aware of the existence of manganese-ore in the Sandur Hills from a reference in a paper by Newbold published as long ago as 1838 ; later he noticed the accounts given by Mr. Bruce Foote in his Memoir on the geology of the Bellary district. Thinking it might be worth while to explore this area, he persuaded his employers, Messrs Jambon & Co. of Calcutta, to allow him to make a personal visit to the Sandur Hills. By visiting the localities mentioned by Foote, which referred to occurrences of no economic value, Mr. Ghose was soon led to the discovery of the Ramandrug deposits now being worked; and, continuing his exploratory work over other portions of the Sandur Hills, he located during the course of about two years' work (1905 to 1907) some 90 to 100 valuable deposits of manganese-ore. An expert was brought out from Europe to confirm Mr. Ghose's opinions as to the value of the deposits, and on this report was floated the General Sandur Mining Company, Limited, capitalized at £320,000. Mr. Ghose estimates that the deposits discovered contain not less

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[1] The full text of Mr. Ghose's paper has been issued as part III of this volume of the Transactions.

than 10,000,000 tons of merchantable manganese-ore. This, the speaker said, seemed a very large figure, and would probably be received as the vision of an imaginative enthusiast. But Mr. Ghose was probably within the mark when he advanced this figure. In 1907 he (Mr. Fermor) had the pleasure of visiting these hills and meeting Mr. Ghose in his camp on the Kamataru plateau situated at the southern end of the range, and perched up 1,000 feet above the plains. During two days of hard work on the Kamataru plateau, they visited nine deposits scattered over this plateau. Every outcrop Mr. Fermor blazed was either manganese-ore, iron-ore or laterite, manganese-ore being by far the commonest rock. During this short space of time he seemed to be living in a world built on manganese-ore, and he thought it probable that they saw at least a million ton of ore cropping out. This seemed a wild sort of statement, but it was based on measurements made on spot.

Although Mr. Fermor thoroughly endorsed most of what Mr. Ghose had written, there were of course various minor points to which exception might be taken, and which would doubtless give rise to discussion amongst the members, when the full text of the paper had become available. But there was one question on which Mr. Ghose and he agreed to disagree—the question of the origin of the deposits. Briefly speaking, Mr. Ghose maintained that they were of *syngenetic* origin, and were deposited from solution in a sea-basin contemporaneously with the associated phyllites and quartzites; the manganese entered the sea in solution in waters derived from disintegrating volcanic rocks containing manganiferous minerals, and emitted contemporaneously with the deposition of the Dharwar sediments with which the ores are associated. Mr. Fermor, on the other hand, maintained that the ores were of *epigenetic* origin, and were formed by the metasomatic replacement at the surface of the Dharwar phyllites and quartzites, by means of percolating manganiferous solutions. The phyllites and slates associated with the manganese-ore deposits frequently contain disseminated octahedra of magnetite. In many cases portions of these phyllites are found partially altered to manganese- or iron-ore, but still retaining their schistose structure, and with the tiny magnetite octahedra intact. From this altered rock every gradation can be found into high-grade manganese-ore still retaining the magnetite octahedra, and also the schistosity planes of the phyllite. Judging from this alone Mr. Fermor thought there was little doubt that such ores have been formed by the gradual replacement of the phyllite, molecule by molecule' by manganese oxide deposited from solution. The source of the manganese is to be found in the phyllites themselves. When tested these are found to react distinctly for manganese. And, according to Mr. Fermor's theory, the manganese dissolved out of a large amount of rock has been concentrated into the form of bodies of manganese-ore by means of this process of gradual replacement. A full exposition of his ideas on this subject would be found in Chapter xxxviii of his monograph on the manganese-ore deposits of India, forming Vol. xxxvii of the *Memoirs of the Geological Survey of India*, so that it was unnecessary to enter into the question in any more detail at this meeting.[1] In fairness to Mr. Ghose, however, he was compelled to say that his ideas on the origin of the Sandur deposits were based only on the Ramandrug deposits, which were the only ones on which any work had been done at the

[1] Since published.

time of his visit. The deposits of the Kamataru plateau are on the whole of much higher grade than those of Ramandrug; and although he thought, judging from the mineral constitution and physical characters of the Kamataru ores, that the theory applicable to Ramandrug must also apply to these, yet he had to admit the possibility of there being among them deposits representing chemical sediments deposited contemporaneously with the Dharwar sediments of mechanical origin. And in any case Mr. Ghose had spent so much time and energy in the study of the Sandur deposits, that his views on the origin of the ores were entitled to considerable weight.

Mr. Fermor then read out a portion of Mr. Ghose's paper containing some controversial matter on the classification of the Dharwars, concerning which he thought Sir Thomas Holland might have some remarks to make. He concluded by congratulating Mr. Ghose on the authorship of a paper that was destined to become one of the classics on Indian manganese-ore deposits.

Sir T. H. Holland considered that Mr. Ghose's paper formed one of the most valuable contributions we have had towards the solution of the difficult question of the origin of our unusual stores of manganese-ore. As a fine piece of descriptive work it will remain of permanent value, no matter to what degree future researches may modify the theoretical conclusions. The paper is exactly of the class that this Institute is expected to encourage—a paper of scientific interest on a subject of immediate commercial value. Mr. Ghose offers explanations that differ from those previously given by Mr. Fermor regarding the Sandur problem; yet in his enforced absence he has entrusted his memoir to Mr. Fermor, who has taken care to give us a full statement of the grounds on which Mr. Ghose bases his conclusions: the way in which the paper has been dealt with does credit both to the Author and to Mr. Fermor, and the whole incident shows the generous spirit that controls our Members. One of the interesting questions raised in the paper is that of the classification of the Archæan rocks: the Author calls attention to the difference between the classification adopted in the new *Imperial Gazetteer* and that accepted by Mr. Vredenburg for his interesting " Summary of the Geology of India."

Mr. Vredenburg assumes that the fundamental gneiss complex represents "in part at least, the original crust of the globe, when the surface of the originally molten mass began to solidify"; and he thus separates from the Archæan the Dharwar system, which includes undoubted sediments. In the geological chapter of the *Gazetteer*, written by the speaker, a more cautious line had been adopted; for there is no proof that the earth has cooled from a molten condition; on the contrary, there is a growing tendency to regard it as a planet which has grown by the accumulation of fragmentary solid matter, that an atmosphere was formed, and that the processes of weathering and deposition began when the globe was hundreds of miles less in diameter than it is at present. Thus, there may have been no such thing as a slaggy crust, and the fundamental crystalline complex may have attained its peculiar characters at depths of only a few miles below the present surface, just below, in fact, the " zone of fracture," which is probably not much more than 6 to 10 miles deep.

The Dharwars in their typical exposures can generally be marked off from the gneissose complex on lithological grounds; but it is highly probable that many of the constituents of the gneissose complex are younger than much of the Dharwars, younger in the sense that they were in a condition of free molecular movement akin to fusion after the Dharwars were deposited. It is also probable that many of the rocks referred to as members of the gneissose complex are really altered Dharwars. Under these circumstances it seems safer to regard the great post Dharwar unconformity as one of the chief lines in any classification based on a time-scale: all the rocks below this line are foliated, and might conveniently be called Archæan; all above this line in Peninsular India appear to have remained above the "zone of flowage", and, though sometimes folded, have not been foliated. Below this line only local time subdivisions are possible; occasionally one can say that a gneiss is older than a Dharwar schist in the same area; but it by no means follows that the gneissis are all, or even generally, older than the Dharwars. All are, however, very old, immeasurably older than the sedimentary systems known as the Cuddapahs, the Gwaliors and the Bijawars: they should be grouped together by some name that indicates this fact, and the name Archæan, originally applied in America to rocks of the Dharwar type, not to the gneissis, is the most expressive. Pebbles of gneissose granite are sometimes found in the Dharwars, showing that ordinary processes of weathering and erosion were in operation when the Dharwars were formed; but these pebbles are lithologically quite different to the gneissose granite of the typical Hosur gneiss, which has been regarded as our oldest gneiss in South India. The Dharwar pebbles are generally of much altered granite and of a kind indistinguishable from the gneissose granite that appears to have been penetrated by the charnockite series to the south of Salem (see *Mem.*

Geol. Surv. Ind., vol. xxx, pp. 107—110, 121, 122). This question is, however, little more than a by-product of Mr. Ghose's memoir, but it has been treated with the thoroughness that characterises the main questions regarding the geological relations of the manganese-ores.

Dr. Sommerfeldt then read the following paper:—

Zeolites from Bhusawal.

BY

Dr. E. Sommerfeldt.

Zeolites are found at many places in India, mostly connected with basalts or weathered trap. Bohna is a place famous for zeolite deposits. You can see in the Indian Museum excellent crystals of this mineral group. I propose to draw attention to a deposit, where I have found not such fine crystals, but which may perhaps have some technical value.

It seems that up to now the natural zeolites have not been used for any technical purpose, but some years ago artificial zeolites were employed in the sugar industry by Harm, Ruemplar and Gans.

As pure zeolites are not very abundant in Europe, these German chemists did not take any notice of the natural zeolite, but manufactured an artificial one. By treating in definite proportions a mixture of certain chemicals, they obtained a mineral similar to a natural zeolite. But in India the use of *natural* zeolites would be preferable and more economical.

The locality under report is about two miles from Bhusawal railway station. Here the river breaking through thick layers of trap, may have assisted in the production of zeolites by decomposing the volcanic rocks. The samples shown are collected just at the intersection of railway line and river; therefore the transport of the material is very easy.

The quantity of zeolites is very large; they are enclosed partly in trap, partly in a quite decomposed trap altered to a red laterite-like mass which can be crushed much more easily than the trap.

The lateritic products may be used in the brick industry or in the making of artificial stones. The zeolites, as they are of a quite different colour, can be easily separated, when crushing, by the native labourers.

That zeolites, which I propose to work as above, can be used in the sugar industry follows from the property these minerals have of being able to change their basic constituents under the influence of solutions of salts. A sodium-zeolite, for instance, can be changed into a lime-zeolite by a solution of lime-chloride or into a barium-zeolite by a solution of barium-chloride, and the calcium or barium-zeolite can be reconverted into a sodium-zeolite by a solution of sodium-chloride. The artificial zeolites have this property and are, therefore, named "permutit" by the firm of Riedel at Berlin, who manufacture these products according to the formulæ of Dr. Gans.

By filtering sugar-juice through calcium-permutit the alkali of the juice would be removed and replaced by lime; the lime can be precipitated, and the juice thus purified yields a higher percentage of crystallised sugar than before; thus the loss of sugar (that is to say the uncrystallisable part of the solution) is diminished.

The sodium-permutit is changed by the same process into lime-zeolite, but can be reconverted into sodium-zeolite by the action of a sodium solution.

Amorphous substances change their alkalies more easily than crystallised minerals; it is, therefore, desirable to melt the Indian zeolites before employing them in the sugar industry.

Lastly, I give here the chemical composition of one of my zeolite samples analysed by me in the laboratory of Dr. C. Schulten, showing that to this kind of zeolite must be given the mineralogical name "desmin."

Silica	56·56	per cent.
Oxide of iron and alumina ..	17·94	,,
Lime	10·00	,,
Alkali, combined water and loss ..	15·50	,,
	100·00	

At present modern methods are being introduced into the sugar industry in India, and this short paper may perhaps help to draw attention to the very modern and hopeful zeolite-method of Dr. Gans.

DISCUSSION.

Sir T. H. Holland considered that the paper might prove to be one of unusual value from a practical point of view, as it certainly is interesting on theoretical grounds. The sugar industry, which would be directly affected by a cheap supply of zeolite, is likely to take a prominent place in Indian industrial questions. The country is now importing refined sugar worth nearly a million sterling per annum from Austria, beside still larger quantities from Java and Mauritius. The last two places possess some of the natural advantages of India ; but the fact that Austria, with a climate less suited to the luxuriant growth of sugar-bearing plants, can force its products at a distance of 4,000 miles into a country like India, where sugar-cane grows like a weed, shows, first, that science can remove the disabilities of climate, and, second, that the same kind of science might be made to supplement the natural advantages of climate. Beside improving the breed of cane and the machinery for extracting the juice, we want methods for increasing the yield of refined sugar ; and Dr. Sommerfeldt has shown that we have a special advantage at hand in the enormous quantity of zeolites now lying idle in the Deccan Trap. Before, however, this material can be turned to account commercially, we wish to know how the cost of extracting and concentrating the natural zeolite will compare with that of manufacturing the artificial material. One may conclude at once that in many of the trap flows, perhaps in most cases, the proportion of zeolite to solid trap-rock will be too small to be worth serious attention ; but it is also true that the zeolitic traps are the most friable among the flows, and there may be enough of the mineral in some cases to meet all requirements, for the lime-zeolite can be artificially reformed from the alkaline product. Without actual trials on a fair scale, we are unable to judge of the commercial value of Dr. Sommerfeldt's proposal, but it seems quite possible that in the near future we shall see prospecting licenses and mining leases granted over areas which hitherto have been regarded as sources only of common building stone.

Meeting at Giridih.

Monday, 13th December, 1909.

An ordinary General Meeting of the Institute was held at Giridih, on Monday, the 13th of December, 1909. Some 18 members were present. Mr. T. H. Ward, Supdt. of the E. I. Ry. Co.'s Collieries, met the party at the station, and took the members to the Ry. Institute, where he gave a short account of the plant to be examined. He then took them by a special train to the new coke-oven bye-product plant. After inspecting the plant very thoroughly, the members went on to the workshops close by, and saw the machinery driven and lighted by electricity generated at the coke-ovens. Amongst other things, a practical demonstration was given of rope-capping, already shown to the Institute at the former meeting at Giridih in 1906 (see pp. 213 to 215 of Vol. I of the "Transactions"). At the end of the rope the wires were twisted out, cleaned, oiled and placed in the capping, which had a conical socket. White metal was then poured in, powdered resin being used as a flux. The ends of the wire were not bent back on themselves, as used to be the practice. Reliance was placed entirely on the frictional connection between the surface of the wire and the white metal in the conical socket.

A point which seems to merit notice is the small attendance at this meeting. The majority of the members present travelled up from Calcutta, hardly anyone coming from the coalfields; and the visit, as has been remarked, almost resolved itself into a Govt. inspection. It is a matter for regret that, although the district visited was, perhaps, rather difficult of access from the other coal fields, so few members took advantage of the opportunity, afforded them by the courtesy of Mr. Ward and his staff, to profit by a personal inspection of a most interesting plant and one which is a new departure in the Bengal coal industry.

The following paper gives Mr. Ward's description of the plant examined :—

Description of the Bye-product Coke Ovens at the East Indian Railway Company's Collieries, Giridih.

BY

T. H. Ward.

(With Plates 25 and 26.)

SLACK SUPPLY.

The coal (slack) received from the Collieries is emptied from the trucks into a 70-ton hopper, at the bottom of which is a jigger feed which passes it into a disintegrator; this machine reduces the slack to an uniform size, suitable for making the cake, for machine charging, in the compressing chamber. The slack is then lifted by means of an elevator and delivered to the top of the storage bunker on to a conveyor which distributes the slack over the length of the bunker. There are also arrangements for adding water to the slack when necessary. At the bottom of the bunker are two rows of sliding doors worked by rack and pinion. Under one row the hopper tubs, used in charging the ovens by hand, can be loaded; and under the other the compressor hopper, from which the compressing chamber is fed, can be brought to be filled up. The "compressor," so called, is a complicated piece of machinery which can be traversed the full length of the battery of 30 ovens. On it is carried the ram for pushing the coke out of the ovens, and also the apparatus for stamping a full charge for one oven into a cake, and for passing this cake into the oven. It is actuated, and all the machinery on it, by electricity, generated by the surplus gas from the ovens used in a gas-engine.

CHARGING THE OVENS BY HAND.

When the ovens are being charged from the top the procedure is as follows:—

The valve on the top of the ascension pipe of the oven which is to be discharged is first lowered, isolating it from the hydraulic main; the covers on the three charging holes at the top are removed; the lifting chains are made fast to the doors, and the "daub" (*i.e.*, the clay-luting with which the doors have been made air tight) cut away. The doors are then lifted, and the "ram," or extruder, is brought into perfect apposition with the end of the oven. The ram then discharges the coke on to the "bench," where it is rapidly cooled by water (under pressure).

The ram, after pushing the coke through the oven, is immediately withdrawn, and the doors at each end of the chamber lowered and "daubed" (sealed, or luted, with clay). The tubs containing the slack for the fresh charge, about nine tons, are then brought over the three charging holes in the top of the ovens, and the slack is dropped in.

The charge is then levelled by means of long rakes pushed through the holes in the end doors, the charging hole covers are replaced, and the holes in the doors hermetically sealed.

The valve at the top of the ascension pipe is now raised, again connecting the unit with the general system. Distillation of the charge at once commences, the gases passing into the hydraulic main. The charge takes about 40 hours to burn off.

CHARGING BY MACHINE.

The cake, or block of coal (some 33 feet by 7½ feet deep by 18 inches in thickness), has first to be formed.

This is done by running coal into the compressing chamber in layers, with the necessary quantity of water, and stamping it with the electrically operated automatic stampers provided.

One side of the compressing chamber can be slacked off, releasing the cake, which is then left standing on the sole-plate of the chamber. This sole-plate (which, by the by, costs more than £100) is rather like a bridge rail in cross section, a rack being formed in the "bridge." It can be traversed right into the oven, carrying the cake on it. The sole-plate can then be withdrawn, leaving the cake, or charge, behind.

PRODUCTS OF DISTILLATION.

After leaving the ovens and entering the hydraulic main, the volatile constituents driven off are drawn, by means of mechanical steam-driven exhausters, through the hydraulic mains into the "gas main." There are two batteries of 18 and 12 ovens. The gas from the 18 ovens (see Plate 25) passes to the right and down through a vertical air-cooler, 23 feet in height, where the first of the tar is condensed, and which is so arranged as to prevent solid particles being carried forward. The gas from the 12-oven battery passes to the left (see Plate 25). The air-cooler has been dispensed with, partly because there are fewer ovens, and the gas goes straight to the serpentine, the first of the tar being trapped as on the other side.

The gas is then drawn through the "serpentine" on either side. This is an arrangement of pipes designed to provide a large area for cooling purposes. Water is constantly sprayed on to this, and the remainder of the tar is condensed. A portion of the ammonia gas is picked up here by the water formed by the condensation of the steam in the gases passing over. This (ammonical liquor) and the tar gravitate, together with the tar and liquor from the air-cooler, into the deposit tank (see Plate 25). After leaving the serpentines, the gas is drawn through the exhausters and is forced through a "Peloux Tar Extractor", one being placed on each side. In this apparatus the last traces of tar—carried in minute particles known as tar fog—are arrested by causing the gas to pass successively through small holes in three concentric cylinders, perforated with numerous holes, which dip into tar and are kept slowly rotating horizontally; the gas passes through the holes in the first cylinder, impinges on the area between the holes in the next cylinder, and so on. The surface of the cylinders, owing to the constant rotation, is covered with a thin layer of tar, and this tar picks up the small particles. The tar caught in these extractors gravitates to the deposit tank; and the gas is forced on towards the scrubbers, where ammonia is abstracted. There are four scrubbers, two on each side. They are cylindrical iron tanks, filled with layers of thin planks placed on edge, over which cold water is constantly running down, so that any ammonia in the gases, which enter at the bottom of the scrubber and pass up through it, is absorbed, cold water having a very strong affinity for it. The ammoniacal liquor (as the water in which ammonia is absorbed is called) is circulated in the scrubbers, until the required degree of concentration has been attained, when it is allowed to run through the "seal-pot" into the "strong liquor" tank. It is then pumped into a storage tank to await further treatment in the Sulphate of Ammonia Plant.

After leaving the scrubbers the gas is forced onwards through "acid washers." These are small lead-lined tanks divided into four chambers. The first two chambers contain sulphuric acid, which picks up any traces of ammonia which may have escaped absorption in the scrubbers; the last two chambers contain water, through which the gas is passed, to prevent any acid from passing over into the return gas-main, where it would soon corrode the pipes.

The gas has now been freed from tar and ammonia, and is used for the following purposes:—

(*a*) A large portion is forced back to the ovens, and there burnt in the flues in the oven walls, to generate the heat required for coking the coal.

(*b*) For driving the gas-engine, for generating the electricity required to actuate and light the plant, and for other purposes.

(*c*) For generating steam in the two Lancashire boilers. Steam is required for actuating (occasionally) the stand-by steam-engine, the exhausters, the steam pumps, and for use in the Sulphate of Ammonia house.

(*d*) The remainder is carried to the 50,000 c.ft. gas-holder, and will ultimately be used in driving the 2—225 H.P. Korting gas-engines which are being installed, and which will generate triphase current for use at distant points on the Collieries for screening, pumping, hauling and lighting.

Under heads (*a*) and (*b*) a few further explanatory remarks are required:—

(*a*) *Gas used for Heating the Ovens.*

The gas is carried in two pipe lines, one on each side on the top of the coke ovens (see Plate 25). Branches opposite each wall, or pillar, between the ovens, carry the gas down to a point below the sole of the oven, where it is distributed from either end, through conduits made of refractory material, to five groups of three vertical flues each (see left-hand side of cross-section of the ovens, Plate 26). Air is drawn in alternately through the regenerator on one side, through the system of vertical flues in the walls between the oven chambers into and through the regenerator on the other side, by the force created by the chimney, which is 160 feet in height. The air is heated up to about 1700° F in passing through the regenerator, and is distributed to the five groups of vertical flues (as shewn in the cross-section on the right-hand side of Plate 26), passing through the three small holes shewn at the top of each of the five distributing chambers, where it meets the gas, which is always turned on the same side as the air supply. Ignition takes place at this point, and the burning gases pass upwards, on the gas and air supply side, through the vertical flues on that side, and downwards through the corresponding five groups of vertical flues on the other side, and onwards—under the influence of the draught created by the chimney—through the passage into the regenerator on the other side (shown on the right-hand side of the cross-section of the ovens, Plate 26). The burnt and hot gases then travel through this regenerator, and the flues shown at the base, into the chimney. It is hardly necessary to point out that this regenerator picks up the heat from the spent gas, and, when the current is reversed (as it is every half hour), and air is drawn in through it for the combustion of the live gas, as described above, again parts with it, so that hot air is available to burn the gas and increase and regularize the heat of the oven walls. The high temperature of the air used to effect combustion of the gas is found to result in a great saving in the quantity of the gas used. A larger surplus is thus rendered available for use in gas-engines, boilers, etc.

(*b*) *Gas used for Driving the Gas Engine.*

The engine—by the National Gas Engine Co.—is of 66 H.P., and drives a (two current) D.C. generator, the pressure between the outside and inside wire being 250 volts., and of course over the outside wires 500. This engine supplies all the electricity required for the crushing and elevating of the coal, the working of the compressor and ram, and for lighting the plant. It also supplies the electricity for the whole of the machinery and lights in the Colliery workshops, a quarter of a mile distant, and for the lights and fans in two bungalows and in the Colliery Superintendent's Office.

SULPHATE OF AMMONIA.

The storage tank into which the strong liquor has been pumped (as already mentioned) is arranged at a higher level than the top of the still in the Sulphate house. The liquor runs first, by gravitation, through a heater, through which the hot waste gases evolved from the saturator are led. These gases are of a very noxious character and are passed on to the chimney. The liquor then runs through a steam super-heater, which further raises its temperature, after which it enters the first still near the top of the column. The still consists of a series of shallow trays which are perforated by 3″ holes covered by hoods or caps, the lower margins of which dip under the liquor held up by the tray. The liquor drops from tray to tray. Steam passes up through the holes, and, baffled by the hoods, bubbles through the liquor, keeping it continuously boiling. The free ammonia absorbed in the liquor is thus expelled (volatilized) and goes forward to the saturator.

The liquor still contains what is called fixed ammonia. This exists in the form of salts (sulphide, chloride, etc.) of ammonia. To free this fixed ammonia the liquor is treated with lime water. This lime water is pumped into the lower portion of the first and larger still and there mixes with the liquor falling down the still. Steam is passed into the mixture, through perforated pipes near the bottom, and the mixture overflows into the second or smaller still, where steam is again passed into it. The freed ammonia rises and passes into the first still, to join that first released, on its way to the saturator.

The saturator is a lead-lined domed vessel where, in an inner chamber, sealed by the sulphuric acid which fills up the lower part of the vessel to a depth of about $1\frac{1}{2}$ feet, the ammonia gas has to pass into the sulphuric acid. It there combines with the acid, and is precipitated as sulphate of ammonia. This salt is fished out of the saturator in copper ladles, and thrown on to a lead-lined tray to drain. It is afterwards passed through a centrifugal drier, driven by a steam engine, and is ready for despatch.

Ammonium sulphate is readily saleable for export to Java and Straits. India has not yet learned to use it, and it is said, by agricultural experts, that this is the reason why Java sugar can beat (in price) the home-grown article in Calcutta.

TAR.

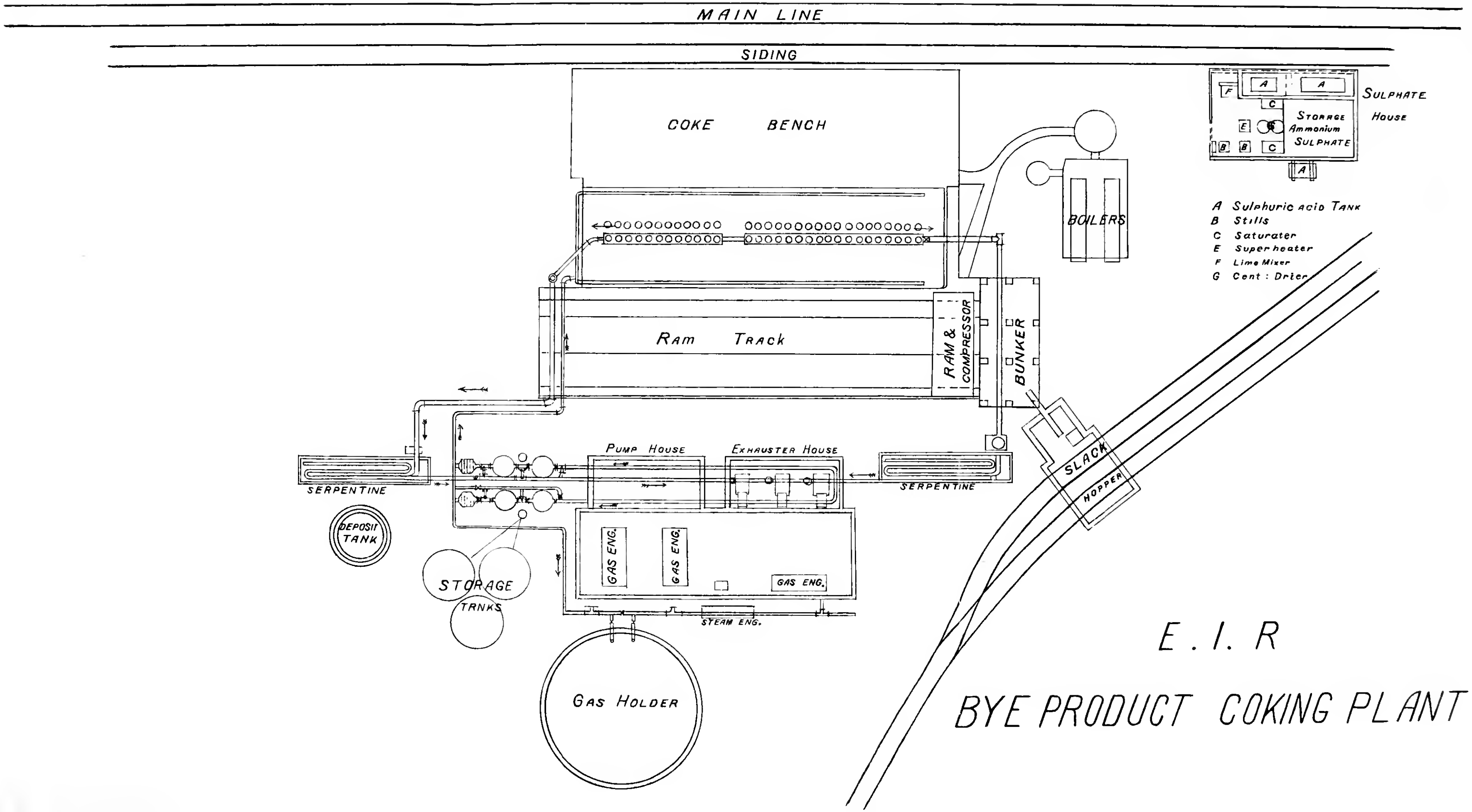
The tar which has gravitated to the deposit tank is first pumped into what is called the decantation tank. In this tank the tar and ammoniacal liquor separate by difference of specific gravity—the tar going automatically into one tank, and the ammonia liquor into another. The tar is then pumped into an overhead tank from which it is filled into barrels, or kerosine oil tins, as required for despatch.

CAPACITY OF THE PLANT.

The two batteries—one of 18 and the other of 12 units—are capable of carbonizing about 50,000 tons of coal a year. In other words they will produce about 40,000 tons of coke. The yield of tar and ammonia cannot yet be said to have been definitely ascertained. The cost of the installation has been over six lakhs of rupees. The cost of the gas engines now being installed to utilize the surplus gas, including the lead to the Collieries, the triphase motors required to substitute the D.C. motors, about 200 H.P., now running, the electrification of the workshops, and the lighting, etc., of three bungalows will cost over two lakhs.

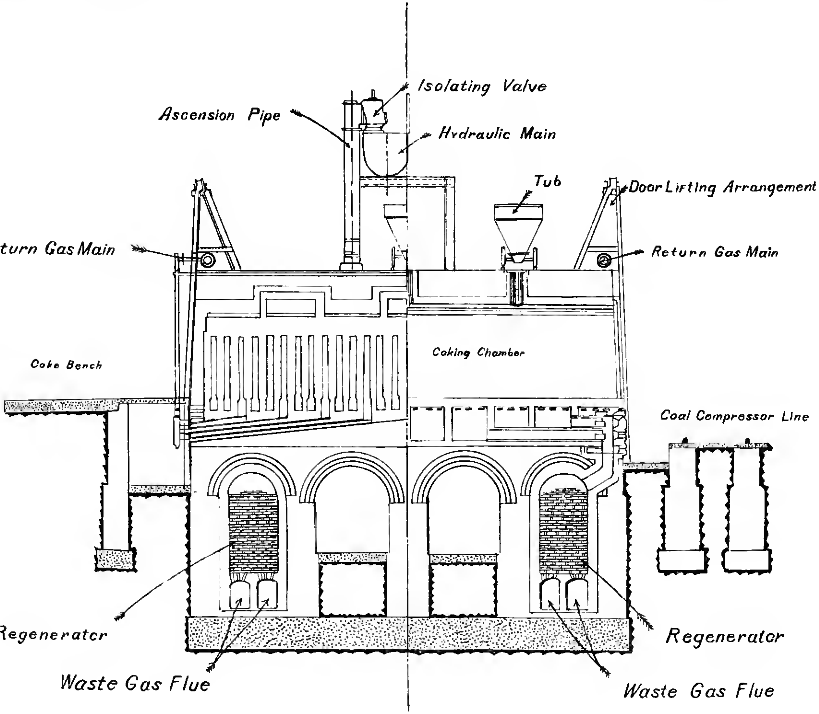
No 1

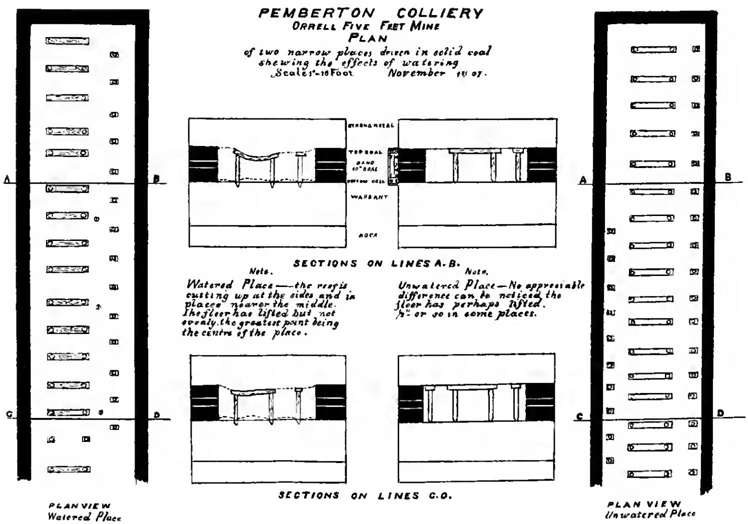
Transactions. Vol. IV, Pl. 25.



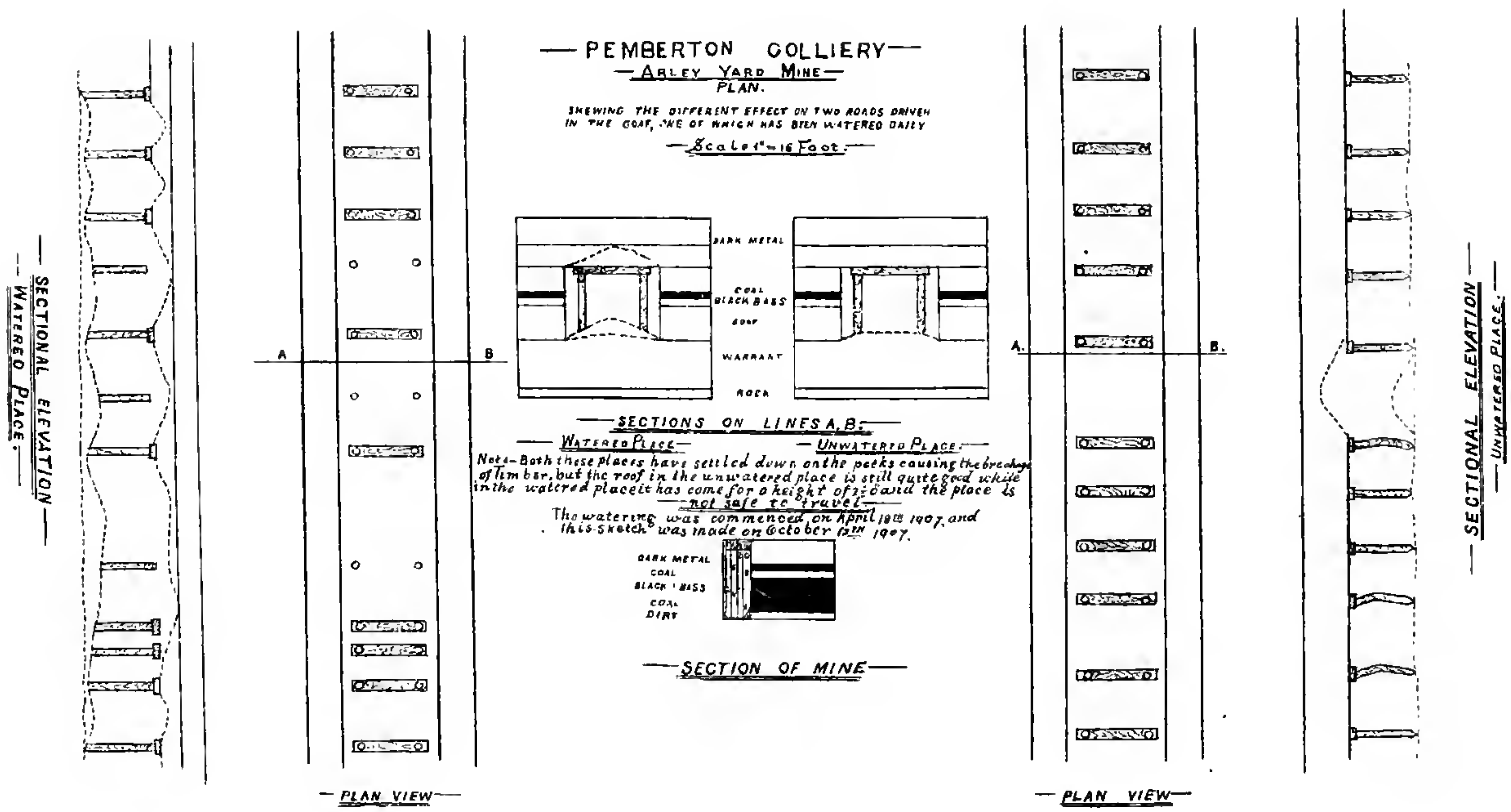
No 2

Section Through Centre Flue & Centre Coking Chamber of Coke Ovens on The E. I. R. Collieries

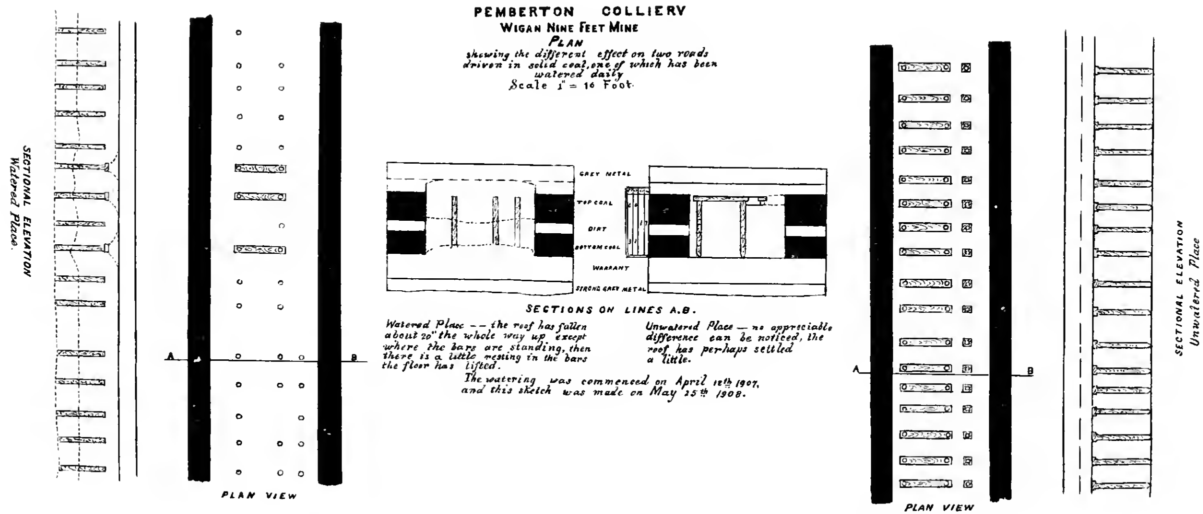



PEMBERTON COLLIERY
ORRELL FIVE FEET MINE
PLAN
of two narrow places driven in solid coal
shewing the effects of watering
Scale 1" = 16 Foot November 1907.
TOP COAL
WARRANT
ROCK
A
B
C
D
SECTIONS ON LINES A.B.
Note.
Watered Place — the roof is cutting up at the sides and in places nearer the middle. The floor has lifted but not evenly, the greatest point being the centre of the place.
Note.
Unwatered Place — No appreciable difference can be noticed, the floor has perhaps lifted ½" or so in some places.
SECTIONS ON LINES C.D.
PLAN VIEW
Watered Place
PLAN VIEW
Unwatered Place

W. J. GREENER. Watering of Roadways in Mines. Transactions, Vol. IV, Pl. 23.



W. J. GREENER. Watering of Roadways in Mines. Transactions, Vol. IV, Pl. 24.



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TRANSACTIONS

OF THE

Mining and Geological Institute

OF

INDIA.

Vol. V.

EDITED BY

LIEUT.-COL. F. CUNYNGHAME HUGHES,

F.C.S., A.I.M.M.

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1910.

CONTENTS.

PART I.

PART II.

Transactions
of the
Mining and Geological Institute of India.

Part 1.] 1910. [July.

Annual Meeting, 1910.

The Annual General Meeting of the Mining and Geological Institute of India was held in the rooms of the Asiatic Society of Bengal, 57, Park Street, Calcutta, on Friday, 28th January, 1910, Mr. H. G. Graves, the retiring President, being in the chair. About 60 members and visitors were present, including the following:—

Messrs. G. F. Adams, T. Adamson, C. T. Ambler, R. Barrowman, F. S. Benson, R. J. Browne, L. M. Chaudhuri, N. M. Chaudhuri, W. A. K. Christie (visitor), Thos. Chrystle, W. R. Criper, Chas. A. Dickson, Geo. Dixon, Dr. L. L. Fermor, Messrs. H. G. Fleury, W. Forster, Glen George, H. G. Graves, W. J. Greener, G. H. Greenwell, W. T. Griffiths, S. Heslop, W. Howarth, Major F. C. Hughes, Messrs. J. S. Kean, T. H. D. LaTouche, G. C. Leach, A. Mackay, J. Mackintosh, S. McMurtrie, C. S. Middlemiss, J. A. Millar, Geo. Miller, Rob. Mitchell, W. O. Mitchell, N. N. Mukherji, M. Munroe (visitor), F. Owen, E. H. Pascoe, T. C. Piggford, G. E.

Pilgrim, G. N. A. Pitt, H. A. Pringle, F. H. Robinson, F. M. Short, G. F. Scott, E. S. Tarlton (visitor), J. Thomas, J. J. Turnbull, H. C. Veasey, H. Walker, C. L. Watson, A. Whyte, and J. R. R. Wilson.

The President, after the minutes of the previous meeting had been read and confirmed, called upon the Acting Honorary Secretary (Dr. L. L. Fermor) to read the Annual Report of the Council, which is as follows:—

REPORT OF COUNCIL, 1909.

The Council have the honour to present the Fourth Annual Report on the working of the Mining and Geological Institute of India.

2. During the year there has been a nett increase of 14 in Ordinary Members, one in Associate Members, and two in Honorary Members and a decrease of two in Associates. The following table gives the numbers since the Institute was started:—

	1906.	1907.	1908.	1909.
Patron	1	1	1	1
Ordinary Members	156	187	219	233
Associate Members	8	16	18	19
Associates ..	3	7	11	9
Honorary Members	2	8	8	10
Subscribers ..	2	6	10	10

3. The following list shows the names and addresses of those who have joined the Institute during the year 1909:—

Ordinary Members.

1. Adamson, M. J., Colliery Manager, Nawpara Colliery, Asansol.
2. Aitken, R., Colliery Mechanical Engineer. Neamutpore, Sitarampur.
3. Benson, F. S., Mining Engineer. Holder of 1st class English certificate of competency. Madhuband Colliery, Nowagurh.

4. Bullock, Victor, Mining Engineer. Holder of 1st class English certificate of competency. Assistant Colliery Manager, E. I. Railway Collieries, Giridih.
5. Chaudhuri, N. M., Colliery Manager. Holder of 1st class certificate under Indian Mines Act. 5, Clive Ghat Street, Calcutta.
6. Connell, R. D., Metallurgical Chemist. Munsur Mine, Kandri P.O., *viâ* Kamptee, C.P.
7. Cooper, A. J., Colliery Manager. Holder of 1st class certificate of competency. Nundi P.O., Raniganj.
8. Crutchett, Ivo A., Mine Manager. C/o Messrs. Thomas Cook & Sons, Calcutta.
9. Field, B. S., Mining Engineer. Holder of 1st class Colliery Manager's certificate. Loyabad Colliery, Bansjora, E.I.R.
10. Finlayson, A., Engineer, Equitable Coal Co., Ld. Jamuria Colliery, Nundi P.O., *viâ* Raniganj.
11. Foreman, C. T., Analytical Chemist and Metallurgist to the E. I. Railway. F.C.S. Jamalpur, E.I.R.
12. Freund, J. J., Mining Engineer. Holder of 1st class certificate. Kannevehalli, Sandur, *viâ* Gudiganuru, M. & S. M. Ry.
13. Fullwood, J. H., Assistant Colliery Manager, E. I. Ry. Collieries. Holder of 1st class English certificate. Giridih.
14. Gillespie, A., Colliery Manager. Holder of 1st class English certificate. Aldih Colliery, Sitarampur, E. I. Ry.
15 Greenwell, G. H., Mining Engineer. Holder of 1st class English certificate of competency. C/o Messrs. Kilburn & Co., Calcutta.
16. Izat, A. H., Civil Engineer. Manager, Central Provinces Prospecting Syndicate. Kamptee, C. P.
17. Kellerschon, J., Resident Engineer for Messrs. Carnegie Steel Company. Nagpur, C.P.
18. Mackay, A., Mining Engineer. General Manager, Indian Collieries Syndicate, Ld. M.E., M.I.M.E. Jamadoba Colliery, Jharia.
19. McMurtrie, S., Colliery Manager. Holder of 1st class English certificate. M.I.M.E. Jogta Colliery, Sijua.
20. Martin, Geo. S., Colliery Manager. Holder of 1st class English certificate. Akhalpur Colliery, Nundi P.O., *viâ* Raniganj.

21. Mitchell, G. K., Colliery Manager. Holder of 1st class certificate under Indian Mines Act. Bejdih Colliery, Sitarampur.
22. Parker, Joseph. Holder of 1st class Colliery Manager's certificate. Bengal Coal Co., Ld., Seetulpur Colliery, Dishergarh, *viâ* Barakar, E.I.R.
23. Pringle, H. A., Mining and Consulting Engineer. Holder of 1st class Colliery Manager's English certificate. M.I.M.M., F.G.S. 12, Dalhousie Square, Calcutta.
24. Sommerfeldt, E., Professor of Mineralogy. Ph.D., F.C.S., F.G.S. 4, Pollock Street, Calcutta.
25. Snelus, J. E., Mining Engineer. A.R.S.M., M.I.M.M. Mahulia, Singbhum.
26. Thornton, J. W., Colliery Manager. Holder of 1st class certificate under Indian Mines Act. Shungamahal Colliery, Mugma, *viâ* Barakar.
27. Turner, Thos., Mining and Mechanical Engineer. M.I.M.E. Caledonia Works, Kilmarnock, Scotland.
28. Vredenburg, E., Assistant Superintendent, Geological Survey of India. A.R.C.S., A.R.S.M., F.G.S., B.L., B.Sc. (France). Geological Survey Office, Calcutta.

Also, the name of Mr. A. G. Bennertz of Adra has been transferred from the list of Associate Members to that of Ordinary Members.

Associate Members.

1. Carey, W. L., Assistant, Messrs. F. W. Heilgers & Co., Calcutta.
2. Longley, F. A. S., Coal Salesman, Messrs. Octavius, Steel & Co., Calcutta.

Honorary Members.

1. Sir T. H. Holland, K.C.I.E., D.Sc., F.R.S., A.R.C.S., F.G.S. The University, Manchester.
2. Dr. W. Saise, A.R.S.M., D.Sc., F.G.S., M.I.C.E., Giridih.

4. The Council note with regret the loss of three

Ordinary Members by death:—Mr. J. A. Savi of Jealgora Colliery, Jharia; Mr. Geo. Shearer of Barakar Brick, Tile and Colliery Syndicate, Ld., Barakar; and Mr. Thos. Turner of Messrs. Andrew, Barclay, Sons & Co., Ld., Kilmarnock, Scotland. Seven members have resigned:—Messrs. R. O. Ahlers, B. L. Brodhurst, R. Collins, W. V. Hannaford, H. H. Macleod, C. A. Prideaux, and Percival Scott.

5. The names of ten members have been removed from the list owing to failure of payment of subscriptions under rule 14.

6. Meetings of the Institute were held as follows:—

Annual General Meeting, Calcutta, 29th January, 1909.
Ordinary General Meeting, Calcutta, 30th January, 1909.
Extraordinary General Meeting, Calcutta, 30th June, 1909.
Ordinary General Meeting, Asansol, 23rd August, 1909.
Ordinary General Meeting, Giridih, 13th December, 1909.

It was also intended to hold a general meeting at Khargpur on the 29th March, 1909, but, owing to the limited response, the meeting was abandoned.

The Ordinary General Meeting at Giridih was held for the purpose of examining the new Bye-Product Coke Oven Plant at the E. I. Railway Company's Collieries, Giridih. The attendance was disappointingly small.

7. At the Annual General Meeting the President delivered a Presidential Address; and at this and the subsequent meetings the following papers were read and discussed:—

(*a*) "Electrification of Dishergarh Colliery." By G. Miller.

(*b*) "The Mining Department of the Civil Engineering College, Sibpur." By E. H. Roberton, M.Sc., B.A., F.G.S.

(*c*) "Notes on the Mining Section of the C.P. and Berar Exhibition." By L. L. Fermor and J. Kellerschon.

(*d*) "Notes on the Waters of Bikanir." By W. H. Pickering.
(*e*) "Coal-Cutting by Machinery." By W. J. Greener.
(*f*) "The Watering of Roadways in Mines and the part Dust plays in an Explosion." By W. J. Greener.
(*g*) "Zeolites from Bhusawal." By Dr. E. Sommerfeldt.
(*h*) "The Manganese-ore Deposits of the Sandur State." By A. Ghose, F.C.S., M.I.M.E.

8. Three parts of the Transactions have been issued, forming part 3, Vol. III, and parts 1 and 2, Vol. IV, under the editorship of the Honorary Secretary. Vol III, part 3, was issued to the members on the 12th July; Vol. IV, part 1, on the 28th August; and Vol. IV, part 2, on the 22nd December, 1909.

9. Six Council meetings have been held during the year for election of members and transaction of the current business of the Institute. The Raniganj Map Committee has continued its work.

The following are abstracts from a report submitted by Mr. R. R. Simpson, Honorary Secretary of the Committee :—

"Mr. Harold Walker, Assistant Superintendent, Geological Survey of India, was in the field from January to April and from November to date. It was originally intended that he should confine himself to the correlation of outcrops of seams and the mapping of faults and dykes proved by colliery workings, but as the material for such work is not even yet sufficient he has been employed in a revision of the geological features of the coal-field. I understand that so far no important differences have been found to exist.

"Since the first distribution map sheets have been issued to nineteen gentlemen, several of whom are non-members of the Committee. More or less completed sheets have been sent in by the following gentlemen:—Messrs. E. C. Agabeg, P. S. Keelan, G. N. A. Pitt, M. N. Roy, and A. Whyte. I take this opportunity to thank them for their work, and to urge upon the other workers the importance of completing the work on the sheets at the earliest possible date. Considerable delays have taken place owing to gentlemen having gone on leave without leaving instructions for the work to be carried on during their absence."

With the sanction of the Council a Surveyor has been appointed with a salary of Rs. 65 per month, assisted by four chainmen at Rs. 8 each. With regard to his work Mr. Simpson reports :—

"He began work near Kalipahari and has surveyed and marked on the sheets the outcrops, etc., lying between Satpukuria and Raniganj. He is now working on the Toposi-Mungalpur-Babisole area. During the rains he was employed for some two months in the drawing office of the Bengal Coal Co. at Raniganj."

10. An Extraordinary General Meeting was held at Calcutta on the 30th June, 1909, to consider the incorporation of the Institute under the Indian Companies Act, 1882, referred to in the last Annual Report of the Institute. The incorporation has now been completed and takes effect from the 16th day of September, 1909. Copies of the Memorandum and Articles of Association were issued to the members on the 22nd December, 1909.

11. The prize offered by the Government of India for the best paper read before the Institute was awarded to and divided equally between Messrs. W. Howarth and Archibald A. C. Dickson for their respective papers on "Longwall method of working coal at the Sitarampur Coal Company's Collieries, Nursamooda," and "Kodarma Mica Mines and Mining."

12. The financial statement shows that the position of the Institute is satisfactory. The revenue of the Institute for 1909 is Rs. 8,950-1-1, the expenditure Rs. 4,416-0-4, leaving a balance of Rs. 4,534-0-9. In addition Rs. 990, the realisation of entrance fees, has been credited to Capital.

FINANCIAL STATEMENT for the year ended 31st December, 1909.

	Rs.	A.	P.	Rs.	A.	P.	Rs.	A.	P.	Rs.	A.	P.
CAPITAL ACCOUNT—												
Balance of last year's account ..	..	..	..	..	..	..	7,320	0	0			
Entrance fees of Rs.												
31 Ordinary Members @ 30 each	..	..	..	930	0	0						
1 ,, ,, @ 15 ..	..	..	..	15	0	0						
3 Associate ,, @ 15 ,,	..	..	..	45	0	0	990	0	0			
										8,310	0	0
RESERVE ACCOUNT—												
23 Life Members' subns. paid in advance	..	..	..	..	..	..	..	..	..	2,810	0	0
LIABILITIES SUSPENSE—	..	..	..	..	..	..	..	..	..	769	0	0
REVENUE ACCOUNT—												
RECEIPTS.												
Balance of last year's account ..	..	..	..	10,879	11	9						
Less Subscriptions for												
1907 not recoverable ..	120	0	0									
1908 ,, ,, ..	285	0	0	405	0	0						
							10,474	11	9			
SUBSCRIPTIONS FOR 1909—												
230 Ordinary Members @ Rs. 30 each Rs. 6,900												
3 ,, ,, @ ,, 15 ,, ,, 45												
18 Associate ,, @ ,, 15 ,, ,, 270												
1 ,, ,, @ ,, 7-8 ,, ,, 7-8												
9 Associates @ ,, 30 ,, ,, 270												
10 Subscribers ,, 200												
	7,692	8	0									
Interest from the National Bank of India	856	14	1									
Sale of Books	400	11	0									
				8,950	1	1						
EXPENDITURE.												
Advertising, Printing and Stationery	1,600	11	9									
Postages and Telegrams	368	12	6									
Dinner Account	179	4	0									
Raniganj Coal-field Geological Map Account	1,225	4	3									
Charges General	446	15	10									
Establishment	480	0	0									
Registration	115	0	0	4,416	0	4	4,534	0	9	15,008	12	6
TOTAL Rs. ..	..	..	..	..	..	..	..	..	..	26,897	12	6

	Rs.	A.	P.
Cash with the National Bank of India	2,546	7	5
Fixed Deposit with the National Bank of India	22,000	0	0
Interest accrued on Fixed Deposits	468	13	1
Cash with Honorary Secretary ..	80	0	0
Outstanding Entrance fees for 1909	165	0	0
Outstanding Subscriptions for 1909	922	8	0
Value of Publications in Stock ..	400	0	0
Outstanding Bills	315	0	0
TOTAL Rs. ..	26,897	12	6

Examined and found correct.
LOVELOCK & LEWES, *Chartered Accountants.* } *Auditors*

Calcutta, 20th January, 1910.

The President then moved the adoption of the Report of Council and the Financial Statement. In doing so, he congratulated the Institute upon their satisfactory nature, especially the sound financial position and the gradual increase of membership. They had had some losses, of which one of the chief was the departure of Sir Thomas Holland, their indefatigable first President, to another sphere of work in Manchester. He had been made an Honorary Member, of which honour he was fully sensible, though he did not approve of losing his vote. Of their financial position more would be said later, as it was fully time to spend some of their accumulated funds in aiding the object of the Institute. During the year the Institute had been incorporated under the Indian Companies Act. That did not greatly affect the procedure of the meetings, but it enabled them to work under the new rules. None of the changes were of vital importance, as they left unchanged the object of the Institute—the promotion of the mining and mineral industries of India.

Of course, there was an unsatisfactory side, chief of which was the poor attendance at some of the meetings; one, in fact, had to be abandoned altogether; at another the attendance was so small that it was characterised as an inspection by Government officials instead of a visit by the members.

Mr. LaTouche, the Honorary Treasurer, seconded the motion, which was put to the meeting and carried unanimously.

Mr. LaTouche then proceeded to refer to the very satisfactory financial position of the Institute, and to the yearly increasing balance. He considered that it was most necessary to do something with this money, and proposed that a start should be made by forming a lending library of technical works for the benefit of the members of the Institute. Mr. J. R. R. Wilson then rose and suggested to the meeting that they should take this opportunity of putting forward a definite motion concerning this library. He proposed that the meeting should grant Rs. 1,000 to start the library. Mr. G. F. Adams suggested that the matter should be referred to the Council, who should form a committee to deal with the question. Mr. Graves asked the members to send in remarks and suggestions for this committee. Mr. Wilson then put forward as a definite motion: "That a Library be formed and a Committee appointed by the Council to deal with the question": it was seconded by Mr. R. Mitchell and unanimously carried by the meeting.

The President then read the Annual Report of the Judging Committee on the papers read before the Institute during the year. The report was as follows:—

REPORT OF A MEETING OF THE JUDGING COMMITTEE ON PAPERS.

Members:—Messrs. L. L. Fermor, T. D. LaTouche and J. R. R. Wilson.

A meeting of the Committee was held on Monday, the 10th of January, 1910, at 27, Chowringhee, Calcutta. All the members were present. The papers considered were those read during the year 1909.

(1) "Electrification of Dishergarh Colliery." By G. Miller.
(2) "The Mining Department of the Civil Engineering College, Sibpore." By E. H. Roberton.
(3) "Notes on the Mining Section of the C. P. and Berar Exhibition." By Messrs. L. L. Fermor and J. Kellerschon.
(4) "Notes on the Waters of Bikanir." By W. H. Pickering.
(5) "Coal-cutting by Machinery." By W. J. Greener.

(6) "The Watering of Roadways in Mines and the part Dust plays in an Explosion." By W. J. Greener.

(7) "Manganese-ore Deposits of the Sandur State." By A. Ghose.

(8) "Zeolites from Bhusawal." By Dr. F. Sommerfeldt.

Of these Nos. 1 to 4 were published in parts 1 and 2 of Vol. IV of the "Transactions"; Nos. 5 to 8 were read, and are now in the press, but have not yet been published.

After discussing the various papers, the Members of the Committee found themselves unanimous in awarding the Government Prize of Rs. 500 to Mr. A. Ghose for his paper "The Manganese-ore Deposits of the Sandur State."

(Sd.) L. L. FERMOR.
(Sd.) T. H. D. LATOUCHE.
(Sd.) J. R. R. WILSON.

The President then explained the change in rules regarding the election of officers in Council. The rule (No. 26) in force before the Institute was registered under the Indian Companies Act (1882), allowed the voting papers to be filled up before or at the Annual General Meeting, and required that they should be examined by two scrutineers. The new rules (Nos. 27 and 28) stand as follows:—

(27) The voting papers shall be returned to the Secretary at least a week before the date fixed for an annual meeting, and no voting paper shall be used unless returned in time.

(28) The Secretary shall examine the voting papers so returned, and shall report the result of his examination to the annual meeting.

In previous years the Council had selected just the number of names required to give a full Council, but feeling that no opportunity was thus given to the members for selective voting, the Council selected this year, in addition to the customary five officers, 20 names for ordinary members of the Council, of which 15 were to be elected. According to rule 20 of the Articles of Association, past-Presidents shall be *ex-officio* additional members of Council. He then called upon the Honorary Secretary to read the result of the ballot. The following was declared to be the Council for the year 1910-11:—

President:

S. Heslop, Superintendent, New Beerbhum Coal Company.

Vice-Presidents:

T. D. LaTouche, Officiating Director, Geological Survey of India.
W. F. Smeeth, State Geologist and Chief Inspector of Mines, Mysore.

Honorary Treasurer:

J. R. R. Wilson, Chief Inspector of Mines in India.

Honorary Secretary:

H. A. Pringle, Mining and Consulting Engineer.

Members of Council:

T. Adamson, Manager, Jealgora Colliery.
P. Bosworth Smith, Superintendent, Tank Mine, Kolar Gold Fields.
R. J. Browne, Manager, Bhowra Colliery. Mining Engineer.
L. L. Fermor, Assistant Superintendent, Geological Survey of India.
H. M. Hance, Manager, Indian Manganese Company.
H. H. Hayden, Superintendent, Geological Survey of India.
B. Heaton, Principal, C. E. College, Sibpur.
Major F. C. Hughes, I.A., Assay Department, Indian Mints.
A. Mackay, Mining Engineer, General Manager, Indian Collieries Syndicate.
Jas. Mackintosh, General Manager, Borrea and Ondal Coal Company.
Geo. Miller, Manager, Dishergarh Colliery.
E. H. Roberton, Professor of Mining, C. E. College, Sibpur.
G. F. Scott, Chief Mining Engineer, Bengal Coal Company.

R. R. Simpson, Inspector of Mines in India.
A. S. Thomson, Manager, Lodna Colliery.
J. J. Turnbull, General Manager, East India Coal Company.

A vote of thanks to the outgoing Council and officers for their services during the past year was moved by Mr. W. T. Griffiths and seconded by Mr. Glen George, and was adopted unanimously.

Mr. H. G. Graves, the retiring President, returned thanks on behalf of himself and his colleagues on the Council. Incidently he took advantage of the opportunity to refer to the difficulties under which they had laboured as regards the Honorary Secretaryship. Mr. H. H. Hayden had acted for several months, but had, at the beginning of November, to visit Assam officially, and at that time he was in the wilds amongst savage tribes under police protection. Dr. Fermor had kindly undertaken to carry on his work until the Annual Meeting, but he, in his turn, had been sent to Lahore in connection with the Industrial Exhibition there, and Mr. Pascoe had officiated for him until the end of December. All those gentlemen had worked well, and it was a matter for regret that Dr. Fermor could not continue to act; unfortunately, he was going on leave, but they were fortunate in securing a good officer in Mr. Pringle; but, as Mr. Pringle was leaving at once for field work in Burma for the next three weeks, it had been arranged that he should not take over his duties until his return to Calcutta. The speaker then vacated the chair, and formally inducted Mr. Heslop, the new President.

The President then delivered the following address:—

Presidential Address.

BY

Mr. S. Heslop.

GENTLEMEN,

It is my very pleasant duty to have to offer you my best thanks for electing me as your President. It is indeed a very great honour that you have done me, and one which I much appreciate; and though I feel I may not be able to do full justice to so important an office, yet nothing shall be wanting on my part in using my best endeavours to do so, and in furthering the interests of our Institution.

The making of a Presidential address appears to be an established rule, which generally prevails in all scientific or other Institutions, and ours is no exception; for, on the contrary, our first President, Sir Thomas Holland, set the seal on this at the inaugural meeting, and while being, as he explained in his address, painfully aware of the precedent he was creating, yet bade us console ourselves with the thought that he was constraining many eloquent successors to undertake a duty they might otherwise wish to evade. I have no doubt he was quite correct, and that there are many of you well endowed with that desirable talent. But, Gentlemen, I lay no claims to any of the gifts of oratory, and must therefore ask your forbearance in my inability to come up to the qualifications referred to by Sir Thomas Holland.

I propose to speak generally on Indian mining, its earlier history, and subsequent developments; but in doing so, it is with a consciousness there is very little that is novel or new, or that I can produce, that will be of much interest to you, for Indian mining advances but slowly, and there are rarely fresh events that happen in the space of a year, in which respect it is very unlike English mining, where there are constantly some fresh problems arising, and to be solved.

The earlier annals of Indian mining are but scanty and unreliable, but the existence of mineral wealth generally seems to have been known from the most ancient times; and as evidence of this I give the following quotation from J. W. McCrindale's "Ancient India," from a translation of a description of India by Megasthenes as far back as 300 B.C.

"And while the soil bears on its surface all kinds of fruits which are known to cultivation, it has also underground numerous veins of all sorts of metals, for it contains much gold and silver, and copper and iron in no small quantity, and even tin and other metals, which are employed in making articles of use and ornament, as well as the implements and accoutrements of war."

The writings of Pliny also shew the existence of gold from the earliest times, while there is reason for believing that the "Ophir" of Solomon from whence went the ivory, the apes, the peacocks, and gold, is to be identified with the Malabar coast. Professor Ball in his great work on Economic Geology, in speaking of Madras, refers to the interesting speculations that had arisen in the discovery of ancient mines in those regions, and also as to its having long been known that there were formerly large hoards of gold in the possession of the ruling dynasties of Southern India. Dr. Burnell, as a result of his translation of the Tanjore Temple inscription, also came to the conclusion that in the 11th century gold existed in extraordinary abundance in Southern India.

The existence of iron ore has been known for many centuries, iron smelting having been common all over India, traces of which can yet be found in many parts of the country. Ball tells us of the famous iron pillar at the Kutab near Delhi, which indicates an amount of skill in the manipulation of a large mass of wrought-iron that has been the marvel of all who have endeavoured to account for it. This pillar is stated to be 23 feet 8 inches long, with a diameter at its base of 16·4 inches, its weight being estimated at 6 tons; while from the inscription it is believed to have been made about A.D. 400, thus affording convincing testimony of the skill that existed 1500 years ago.

The working of this large store of mineral wealth, known as it was from the most ancient times, and diversified as it is, and spread over great areas of this vast country, is growing in importance, and gradually assuming greater proportions, the latest statistics shewing that the total value of minerals raised during 1908 was £7,823,745 against £7,079,708 in the previous year. The total value of coal was £3,356,847, this being the largest, gold coming next with £2,177,847. The total value of minerals produced in 1902 was £4,549,630, thus shewing a remarkable expansion of the mineral industry.

I now turn more especially to the subject of coal. From the fact of gold and other minerals having been known to exist from the earliest times or over 2000 years, we cannot but suppose that coal was also known from early times in a country like India with the ancient civilization evidenced by its great and ancient buildings, and its arts and manufactures of past centuries. Outcropping seams are much in evidence in many of our coal fields, shewing at the surface on hill sides or ravines, thus affording every opportunity for the discovery of coal. There does not, however, appear to be any authentic record of its existence having been known for much more than a hundred years.

Mr. F. C. Danvers in his "Coal Economy" quotes from a natural history of the mineral kingdom in 1789, in which the author writes:—

> "I am really concerned for the honour of coal; it is an interesting subject, especially in India, and as very little relative to what is herein recorded has been said about it hitherto, that I know of, I reckon the subject my own, and therefore I wish to be its faithful historian."

Coal appears to have been discovered in the Raniganj field in 1774, and was thereafter worked in 1777, while by 1830 several Collieries had been established. The earliest mention of this field, as referred to by Dr. Blanford, seems to have been in a paper by a Mr. Jones, who first opened mines in 1815 at Raniganj itself, though other Collieries had previously existed more to the West. Ball in his Economic Geology refers to the fact, that though coal mining had been in operation for more than a century, the development of the coal resources of the country was yet in a very imperfect condition, for the reason that most of the coal fields were too remote from the ports and centres of manufacturing industry, to render it possible that their coal could be carried to places where it would have to compete with better qualities of fuel brought from Europe. He, however, anticipated that with the extension of lines of railway to the central parts of India, some of these fields might be opened hereafter, and the increased facilities for carrying might render it possible to establish works for the reduction of metallic ores and other purposes, which would increase the demand for fuel.

In the absence of the necessary railway facilities, the expansion of the coal industry for many years was but slow. From 1815 to 1860, or a period of nearly half a century, the output of India had only reached the insignificant annual total of about 370,000 tons. The extension, however, of the East Indian Railway from Pandooah to Raniganj, which was opened in 1855, had given a stimulus to the industry; for until that time the only mode of transit of coal was by boat on the river Damuda, which of course could only be carried out in the rainy season. Some years afterwards was opened the Chord Line, which finally tapped and formed the main trunk of the great Raniganj coal field, and from which branches into different parts of the field have more recently been opened. Other railways have gone on and works and factories have been opened, the expansion of the coal trade having gone on in sympathy. Railways generally have made marvellous progress within the last 50 years. In 1857 there were only 300 miles open. In 1877 there were 6000 miles. By 1897 upwards of 20,000 miles had been opened, while at the present time there are over 30,000 miles in existence, thus forming a network of railways throughout the length and breadth of the country. The predictions of Ball have been fulfilled, for with this expansion of railways, coal mining, and the coal trade, have developed also.

In 1872 there were still but few Companies at work in the Raniganj coal field, consisting practically of five, the Bengal, Raniganj, Equitable, Burrakur, and Beerbhoom, together with a number of small and native-owned concerns, some 44 mines being given in all as working, of which rather more than half turned out less than 10,000 tons per annum. Since then, and more especially in recent years, the number of Collieries opened and Companies floated, assisted by the opening of the Jharia coal field in 1893, with expansion of railways in other districts and Provinces, has been enormous, there being according to the latest statistics some 129 Joint Stock Companies in existence in India, representing an aggregated ordinary capital of Rs. 867 lakhs.

This great development of the coal mining industry generally, and specially within the past decade, speaks for itself, and is reflected in the output; for while in 1870 it was only about half a million tons, in 1890 two millions, and in 1900 six million tons, it had risen to 12¾ million tons in 1908, of which 90 per cent. was raised in Bengal, about 6½ million tons, or more than half, being from the Jharia field; the Raniganj field, which had held the first place up till 1905, now standing second with an output of about four million tons.

The coal trade of the world generally has made rapid strides within recent years, the output having now reached the enormous total of about eleven hundred million tons, the last 10 years shewing an increase greater than that of the 20 years preceding it. In 1897 the output was 633 million tons; in 1887 it was 442 millions; while in 1877 it amounted only to 290 million tons. These figures are abundantly illustrative of, and bear ample testimony to, the growth of the coal industry and trade of the world. The United States shews by far the greatest increase, and takes first place in output, having displaced Great Britain from that position since 1899, the latter now holding second place with 267 million tons, as against 428 millions for the United States, which shews the wonderful increase of about 250 million tons within the last 10 years. Among our more Eastern rivals in production, Japan shews a steadily increasing development. In 1885 the outputs of Japan and India were almost equal. Since that time, however, the output of Japan has shewn a greater rate of increase than that of India, which it now exceeds by about two million tons.

The industry itself reached a maximum in price of coal some two years ago unprecedented in its history, numerous Companies being floated on the strength of it. There were about 50 Companies with an aggregated capital of 283 lakhs started in the official year ending March 1908, or an average of about one in every week, the record being attained in February of that year when some 14 Companies were registered, or one every other day. The previous year saw an average of about one nearly every fortnight, while prior to that, it had not reached an average of one a year in the whole history of mining and Joint Stock Companies. The demand had exceeded the supply. There was a coal famine in the land, and anything that was black seemed to sell so long as it would burn. Old abandoned places were re-opened and new places started, often regardless of quality. The prices for properties and establishment of new Companies assumed proportions something of the nature of a panic, or something like that of the gold boom of Chota Nagpur some years ago; and so eager were the public to get in, and so afraid were they of being left out of these golden opportunities as they believed them to be, that the floating of a coal Company became quite the easiest thing in the world. This sudden and enormous increase of coal Companies with the capital invested received, however, a heavy set back over a year ago, when a sharp decline of demand and prices set in, with a resulting slump in shares, which speculators became as anxious to get rid of as they had been to take up. Many of these new concerns were floated on enormous capitals, out of all proportion to their size, with in many cases too little working capital left—after the high prices demanded for them had been paid—to develop and keep them going, or to venture on deep sinkings, which with the lesser demand it had become all the more necessary to do for the better class coal. It was, in fact, impossible for most of these newer concerns to compete and hold their own with the older, well-established Companies, with strong financial position, large properties, and good coal, with the result that many were closed down or considerably restricted. In many cases, most of the profits made in these good times were paid away in dividends, the excellent opportunity of building up and strengthening the concerns against a rainy day being lost. The commercial paper *Capital*, a few months ago, gave a comparative statement of prices of some 22 Companies compared with a year before, shewing a shrinkage of value on them alone of nearly five crores of rupees. Since that time, fortunately for the investor, a change for the better has again set in. Coal prices have improved, and the industry is in a more flourishing condition. The strike in Australia has enabled us to ship coal there and get to the Straits Settlements, to which it is hoped only good coal will continue to be sent in view of permanently retaining the hold. The working up of an export trade is undoubtedly of the greatest importance, for though doubtless inland consumption will largely increase with the extension of railways and the expansion of our industries, we shall, nevertheless, for any great increase of output producing a surplus, have to look to the export trade to foreign ports. And if a policy for the future be pursued of sending to these ports only our best coal—which I believe will hold its own with that of our competitors—

instead of the inferior coal that has often been sent previously, the good name would be re-established, and we should be able to retain a lasting footing. Generally, I think, with the improvement of the trade of the world and the abundant crops, we may look for prosperous times for the Indian coal industry.

I now come to other matters and will take first and foremost the question of *labour*. This question is doubtless one of the greatest problems we have ever had to face, and still have to face. It is always with us, and is becoming more acute than ever. With the abundant crops and expansion of mining generally, and the consequent increasing competition for a limited supply, there is the natural tendency to advancing rates for mining and all other classes of labour, and consequently increased cost of production. While there is not only the natural scarcity, abour has also from time to time been very seriously affected and depleted by epidemics of cholera and smallpox, especially the former. Two years ago we experienced the most serious cholera epidemic that ever visited the coal fields; it was especially severe in Jharia, where Collieries are much more congested than in the lower field, segregation being consequently more difficult. The consequences of this were so disastrous in Jharia, that the Chief Inspector of Mines in his report estimated the loss of output as over a million tons. The best remedy of this is receiving the serious attention it requires; but it is a problem that is attended with considerable difficulty, for though many are willing and are doing much in the way of filtered water supplies, the desired effect will be greatly minimised unless all participate, both in the immediate neighbourhood of the congested area, or wherever epidemics are likely to occur. There is also the difficulty that cholera often originates and spreads from villages, the property of zemindars over which the collieries have no control, and wherein exist stagnant tanks, with an insufficiency of good wells. If the output of India has to expand, we must secure more labour and get over the difficulties attending it by all possible attractive methods, such as the laying of haulage ways and tramways well up to the working faces and other general facilities, which will not only enable the labour to perform more work by making it easier, but will attract more to the work itself. Good housing is also of much importance, with due regard to the fancies of the miner as to site and style, for the Sonthal still loves his little detached hut with a plot of land around it for a garden—the position of which he likes to choose for himself—in preference to the more modern brick lines which do not afford him the same privacy. The discouraging feature of all this is, that while we go to the outlay of making the work as attractive and as easy as possible, the miner does not reciprocate by giving a correspondingly additional result; but we may console ourselves that if we did not do it, we would not succeed in attracting nearly as many to the Colliery, as we otherwise would.

Beyond all this, the day will no doubt come, when we will see the use of mechanical labour-saving appliances to compensate for the labour shortness, much more generally adopted than at present. The necessity of this will be more especially felt in the deeper mining of the future, in order to maintain the output of the finer quality seams; for I fear there will always be a difficulty in obtaining sufficient labour for this deep mining to give the large outputs required to repay the heavy capital expenditure. Coal-cutting by machinery would undoubtedly appear to be an immediate remedy, for it saves labour. That there are difficulties, however, militating against its introduction is an undoubted fact, for our very conservative miner, strong in the traditions of his ancestors, is averse to change of any kind, and says he has not asked for the work to be made easier. It is not his seeking. It is an innovation, and he does not see why he should not have the usual rate per tub for filling it, as if he had done the whole of the getting down of the coal himself. If we are too insistent all at once, on his being paid a rate in proportion to the work actually performed by him, his independence is so great that he may suddenly take up his bed and walk and go to another place, where he may be perfectly certain of receiving a most cordial welcome, and in getting a very pressing invitation to prolong his stay. But we will have to, and I hope we can, by tactful handling of the labour, and with perseverance, gradually break down these prejudices. It is surely impossible, but that the miner will eventually accept a lower and proportionate rate for the easier work. In fact, I know of certain cases where he has. The machine will cut much more quickly than the coolie can, leaving more labour for the handling of the coal. Another very important factor is that it is much less wasteful than the ordinary means of hand labour, for the Indian miner has no regard for the life of the seam or property, the wide cut he takes in the kirving causing a heavy proportion of dust and loss of larger coal. The introduction of coal-cutting machinery, in consequence of the difficulties and prejudices against it, has doubtless up to now made but little headway. Its adoption, however, was at first only very slow in England, but it has recently shewn much more rapid extension of its use. It is known to have been actually introduced into English mining some 50 years ago, yet up to 1902 there were only 483 machines in use giving the very small output of something less than four million tons or about 1·8 per cent. of the total. A much greater rate of progress has, however, been made since then, for in 1908 the number of machines had increased to 1659, giving an output of 13,508,000 tons, which, though still a comparatively small proportion of the total of 261 million tons, yet shews a very substantial gain over the previous year, when with the larger output of 267 million tons, the machine-cut coal was less or only 12,877,000 tons. This shews that the difficulties and prejudices that had attended its use for many years in England are being overcome, and I am hopeful that with perseverance and the gradual training of the workmen these difficulties will also be surmounted in India, and that it will eventually be successful.

I have now spoken of the general development and present condition of the Indian coal industry as a whole, and would only supplement this with a few more immediate details of the changes and progress of the actual mining during the many years I have been engaged in it. When I arrived in India over 20 years ago, among other first impressions, I was struck with the shallowness of the pits, their number, and closeness to each other compared to that of Home mining. At that time 300 feet was looked upon as a very considerable depth, while now depths of 800 and 900 feet are being reached, with still greater depths in contemplation. In some cases the old-fashioned Gin was still in use, while it shewed signs of having previously been extensively used, the evidence of which may be seen to this day by the numerous upright brick pillars in the Raniganj district that formerly supported the Gin Beam. I was specially impressed too with the smallness of pillars that generally prevailed in the first working of the coal, and especially of shaft pillars, which seemed to me quite inadequate. The smallness of pillars would not bear any subsequent working without risk of thrust carrying over large bodies of workings. Extensive areas have been lost by thrust or fire, in the absence of adequate provision for isolation. Pillars of sufficient size are now being left in the first working ; and with improved methods in their subsequent getting, a much greater proportion of coal is won. By keeping in sight means of separation or isolation, and taking advantage of dykes or faults, or by working in panels or districts, there is, and will in the future be, much less risk of losing valuable areas of coal by thrust or fire. Quarrying was a favourite form of work ; this is generally a most ruinous system for a Colliery, causing as it does constant and heavy inlets of water, entailing a permanent extra cost for pumping as long as the Colliery or property lasts. Evidence of this can yet be seen in long lines of quarries along the outcrops of valuable seams. This practice is now but little resorted to. The workings to the dip invariably extended hundreds of feet from the shaft levels without mechanical haulage, over which distances therefore the coal had to be carried to the tramlines by hand. The use of underground mechanical haulages has since, however, been much more generally adopted, thus effecting a great saving in manual labour. Electricity has been introduced for haulage, pumping, and lighting, and we shall doubtless soon see its use very largely extended, especially with deeper pits having great distances to pump the water, and to haul the coal from. We shall, probably, with the greater depths of pits, have more fire-damp to deal with, which will necessitate the much extended use of mechanical means of ventilation, and the systematic coursing of the air. With the increasing dryness of the pits the serious dangers of coal dust will also have to be reckoned with. I anticipate, also, that we shall in due course see the working by longwall more generally adopted in seams adapted to the purpose. The system is being carried out successfully at the Nursamuda Colliery, a valuable paper having been contributed by Mr. W. Howarth on its working. Since its commencement a coal-cutting machine has been introduced with conveyors, a combination which doubtless constitutes some of the most up-to-date mining yet known in India. The matter of waste in mining will also receive greater attention in the future, in view of making more large coal and less dust, together with greater economies in the present-day heavy consumption at the Collieries. The recovery of Bye-Products from the coking of coal has been introduced, and no doubt will gradually extend.

In addition to the improvements referred to above, Indian mining has also undergone, especially within the past decade, and is still undergoing, changes for the better in other respects; its status and that of the Mining Engineer having been raised to a higher level, while mining education is receiving much greater attention. This very Institute, the Mining and Geological Institute of India, was successfully launched on the 16th of January 1906, and has already done great service to the mining industry of the country, and it will, I hope, continue to do so during the entire future of Indian mining. The Indian Mines Act came into force in 1901 and has been productive of much good in causing mines to be better managed generally; and the fact that all must have certificated managers is in turn causing great advance in mining instruction, Government providing the facilities. That important Institution, the Sibpur Engineering College, is providing an excellent opportunity for a sound training to young men of the country. Classes have been established to afford theoretical training in the principles of mining, while the annual camp in the cold weather at the mines is of much assistance to students, by enabling them to see mines in actual operation.

A scheme was also introduced at the beginning of 1906 for courses of lectures at various centres of the Raniganj and Jharia fields, in view of enabling mine officials to get the necessary technical knowledge to qualify for certificates of competency as mine managers, and to improve the standard of mining knowledge generally. It speaks well for the success of the lectures, and the advantage taken of them, that a number of the students attending have afterwards sat for the examinations for mine managers with excellent result, for of the 86 persons to whom certificates have been granted of both classes, no less than 73 have attended the courses of lectures.

In order to provide the opportunity of acquiring technical knowledge by those who do not know English, the Mining Advisory Board some time ago had under consideration and recommended, that the compilation of a Vernacular Text Book on practical coal-mining should be taken in hand. There would undoubtedly be a great demand for such a work, for there are many Bengalees and up-country men, who, though they do not know English, are good and intelligent pitmen, and who would doubtless be very eager to avail themselves of such a book, and the instruction and benefit it would afford.

My remarks would not be complete in speaking of the progress of mining and the improvements attending it, without a reference to Ambulance work, which the Chief Inspector of Mines in his report of last year referred to, as requiring greater prominence. This I am pleased to say it is now receiving, for a course of lectures has already been commenced in the Raniganj coal field for the instruction of mine officials in rendering first-aid to the injured in case of accident. This is a very desirable step, for doubtless a knowledge of rendering timely aid may often be the means of saving a man's life, in as well as relieving suffering, and is, therefore, worthy of every encouragement and support.

I will now refer briefly to the working of the Institute. During the past year there has been a fair increase of new members, and I hope the present will shew a further considerable addition to our numbers. From the report just read, the financial position is entirely satisfactory. An important step has recently been taken in the arrangement to establish local meetings for the discussion of papers at local centres, such as the Kolar Gold Fields, the Central Provinces, and the Raniganj and Jharia fields. This, I am confident, will prove an excellent plan, for I have every hope of its being conducive to the much fuller discussion of papers. A satisfactory beginning is already being made in the contribution of papers for the present year, and I hope this is only the beginning of a number of others to come.

In conclusion, gentlemen, and in again thanking you for the honour you have done me, I can only assure you I will do my best for the good of the Institute, and with your hearty assistance and support, I shall have every confidence of success.

A vote of thanks to the President for his address was moved by Mr. C. T. Ambler and seconded by Mr. C. S. Middlemiss. The meeting then proceeded to the reading and discussion of the papers on the programme. The first paper on the "Draft Plans for Panel Working" by Mr. Glen George was postponed until the next meeting, as the diagrams to illustrate this paper had not yet arrived from the printers.

Mr. T. D. LaTouche then read the following paper on the Geological Museum, to which an excursion had been arranged for the next day:—

History of the Geological Museum, Calcutta.

BY

T. H. D. LaTouche, B.A., F.G.S.

The early history of the Geological Museum in Calcutta is intimately bound up with that of the Asiatic Society, whose hospitality we are at present enjoying. It was only natural that, soon after the foundation of the Society in the year 1784, the idea of starting a Museum for the housing of the various curiosities that were sent by members from all parts of the country should have arisen, and we accordingly find that in 1796 a proposal was made for hiring a suitable house for their reception. It was not until 1814, however, that the project took more definite shape, when Dr. Wallich offered specimens from his own rich collections in order to form the nucleus of a Museum, and the Society adopted his recommendations. In that year a resolution was passed to the effect that "the Asiatic Society determine upon founding a Museum for the reception of all articles that may tend to illustrate Oriental manners and history, or to elucidate the peculiarities of art or nature in the East." Ores of metals, native alloys of metals, and minerals of every description were specially included in the list attached to the resolution, and the collection rapidly increased. Dr. Wallich was appointed Curator of the geological and zoological section, and held this post for several years.

The whole of the collections were at first housed on the ground floor of this building, but by 1835 we find that they had accumulated to such an extent that it became necessary to discuss proposals for converting the Society's Museum into a national concern, and to employ a paid Curator, Government sanctioning a grant of Rs. 200 a month for this purpose, to which the Court of Directors added Rs. 50 a month for preparing specimens and maintaining the collection in order. Up to this time the whole of the collections, archæological, geological, and zoological, were kept together and under the charge of one person, but the opening up of the Raniganj coal-field and the reports of Dr. Helfer and other scientific officers had directed so much attention to the mineral resources of the country that it was resolved to establish a Museum of Economic Geology, and it is accordingly at that time that we must consider that our Geological Museum was founded.

In 1841 a typical collection of mineral specimens was brought out from home by Captain Tremenheere, and placed in the rooms of the Society in charge of Piddington as Curator. This arrangement lasted till 1856, the original collection made by the Society and the nucleus of the national collection being kept together, but at this period the geological section had so outgrown the accommodation provided in these rooms that Government determined to remove the Museum of Economic Geology to a new site. The Geological Survey, with which its subsequent history is intimately connected, had only recently been established as a separate Department, though several enthusiastic geologists had either been employed by Government, or had spent their leisure time, in surveying and reporting on various parts of the country. Among the most conspicuous of these were perhaps Dr. Voysey, the first geologist employed by Government, in 1818; Mr. Williams, who first examined and reported on the Raniganj coal-field, and whose original Journals, covering the period from December 1846 to just before his death in 1848, are preserved among the records of the Department; Dr. Andrew Fleming in the Punjab Salt Range; Sir Joseph Hooker in Sikkim; Dr. Carter, who in 1857 published a "Summary of the Geology of India between the Ganges, Indus, and Cape Comorin"; and lastly, Dr. McClelland, who immediately preceded Dr. Oldham and the regular Survey, and continued Mr. Williams' work in the coal-fields.

It is recorded that when Dr. Oldham came out to this country in 1851, he found that the whole staff of the Survey consisted of one peon and one writer, and that all records were kept in a single box at the Surveyor-General's office.

But to return to the Museum. In 1855 a house was taken on a three years' lease by Government, at a rent of Rs. 370 a month, at No. 1, Hastings Street, and was fitted up as a Museum and Office for the Geological Survey. Correspondence between Dr. Oldham and the Council of the Asiatic Society, who refused at that time to allow their own collections to be moved to the new building, because they thought that by doing so the proposal for a national Museum would be indefinitely postponed, will be found in the Proceedings of the Society for August 1856. The Museum was thrown open to the public on the 1st January 1857. In a note on the new departure inserted in the first volume of the Memoirs of the Geological Survey, Dr. Oldham defines the objects of the Museum, and it appears incidentally from this that it was proposed to house the institution later on in the new buildings of the Calcutta University. A set of rules for the admission of the public is added, and as the first of these states that visitors are requested to enter their names and number of party in a book provided for that purpose, it may be conjectured that no great influx of the native population, such as is now to be seen any day in the Imperial Museum, was looked for. The attendants were also strictly forbidden even to speak to visitors—rather a drawback, one would think, to people of an inquiring turn of mind.

From the old registers it appears that the Hastings Street Museum contained about 1500 specimens of minerals and rocks, but these probably refer only to the specimens exhibited, as there were also 104 cases unpacked in the godown. The collections rapidly increased, as the members of the Survey, now a round dozen strong, began to push their inquiries into all parts of the country. Of all those who were then on the staff, Mr. R. Bruce Foote is the only member who still remains in the country, having retired and settled in Yercaud in 1891, while Mr. F. R. Mallet, who joined in 1859, is the only other member still alive. What the conditions of such work were in those days may be conjectured from the fact that, of 23 geologists who were appointed between the years 1846 and 1859, no less than nine died on service, and of these seven died within three years of their appointment.

The requirements of the Survey soon began to outgrow the accommodation in Hastings Street. In most of the annual reports submitted by Dr. Oldham between the years 1859 and 1868, reference is made to the inconvenience of the building and the impossibility of exhibiting the specimens to good advantage in the small and badly-lit rooms of a private house; but it was still many years before relief was afforded. Although the removal of the geological collections had enabled the Asiatic Society to devote more space to the accommodation of their remaining sections, the care of these had already become an unmanageable burden. More room and a larger staff than the Society could provide were required for their preservation, and the Society soon began to correspond with Government regarding the foundation of an Imperial Museum at Calcutta. The breaking out of the Mutiny retarded the consideration of these proposals for a time, but in 1862 Government announced that the time had come when the duty of providing a public Museum should be taken in hand, and conditions were settled under which a Board of Trustees was appointed to take over the Society's collections. It was not until 1875, however, that the geological collections could be moved to the present imposing building in Chowringhee, the old quarters being vacated on the 30th September in that year, and on the 1st January 1877 they were thrown open to the public.

In their new quarters the collections rapidly expanded, and even within a few years, in 1881, when I first came out to this country, the space at our disposal was well filled. It was some time before a definite system of registering specimens was adopted, and the earlier methods were somewhat peculiar and confusing. Each officer selected a serial number under which he registered his specimens as he brought them in from the field; thus one specimen only might be registered under one number and perhaps even a thousand under the next, so that there was no ready means of discovering what the total number might be. In one instance Mr. Hughes complains that Mr. Willson has 'bagged his number,' and he is therefore obliged to register his specimens in red ink. In

1867 the present system was adopted, in which each serial number or letter includes beneath it about 1000 specimens, so that a glance at the last entry will show the approximate number of specimens in the collections. We have now about 10,000 specimens of minerals, 23,000 of rocks, and no less than 42,000 of fossils, including besides Indian forms large collection from other parts of the world. The collection of meteorites has always been one of the most interesting features of the Museum. It was started in 1865 by Dr. Oldham with the purchase of specimens of 223 falls collected by Mr. R. P. Greg of Manchester, and now contains 409, a considerable number of which have been found, or have been seen to fall, in India itself.

The task of arranging and labelling the collections in the first instance was an arduous piece of work, in which Mr. Mallet, Mr. Lydekker, and Dr. Feistmantel took the largest share. It was carried on for many years, and it was not until 1883 that guides to the whole of the collections were completed. Since then the history of the Museum has been one of continued expansion. In 1890, on his arrival in India, Sir T. Holland was appointed Curator, and with characteristic energy set to work to classify, arrange and re-label our collection of rock-specimens, at the same time selecting a series of minerals and models for the use of the students of the Presidency College, a branch of our work that has steadily grown under his influence. He was in charge of the Museum for six years, and during that time he re-registered the whole of the rock and mineral collections, then amounting to over 18,000 specimens, and published a new edition of the guide dealing with them.

Closely connected with the work of the Museum has been that of the Laboratory, which has also been from the beginning in charge of the Curator. From the first the determination of minerals, rocks, and fossils sent in by members of the public as well as those collected by the staff of the Survey has been one of the principal objects to which attention has been devoted. Of late years the number of determinations made has enormously increased. Whereas from 1882 to 1890 the average was about 50 a year, during the five years ending in 1908 it was 790, and in 1907 it reached a total of 1092. In connection with this I must mention the excellent work done by our Assistant Curator, Mr. T. R. Blyth, who was appointed under Mr. Mallet in 1884, and has carried out with great efficiency and zeal a very large proportion of this work.

It has not yet been found possible to bring the arrangement of the fossils up to the same standard as that of the rocks and minerals, for we are constantly obliged to send collections to Europe for description, and until these are returned, no comprehensive system of classification can be adopted. The series of Gondwana plants, described and arranged by Dr. Feistmantel, who was Palæontologist to the Survey from 1875 to 1885, is however, in good order, and I have no doubt that it is in this section of the palæontological branch of the Museum that you will be most interested.

DISCUSSION.

Mr. Ward's paper, "Description of the Bye-Product Coke Ovens at the E. I. Ry. Collieries, Giridih," having been read at Giridih, was then opened for discussion.

Mr. LaTouche drew attention to the waste of the bye-products of coke manufacture that was still going on in the Bengal coal-fields, in spite of the example set by the East Indian Railway Company at Giridih. No doubt, the sight of blazing heaps of coal added to the picturesqueness of a journey through the coal-fields at night; but it was melancholy to think of the waste that was taking place. In order to show how little improvement had been made on ancient methods, he quoted a passage from Mr. Blanford's account of charcoal-making in Orissa. "For this purpose, after cutting down their trees (generally selecting the Sal, probably as affording most conveniently logs of a suitable size), the natives loosely build up a large pile of logs of small size, to which, without any further precautions, they set fire, and allow it to burn freely, all the better pleased if a wind be blowing, as then the cremation proceeds more rapidly. When the pile is considerably diminished, water is thrown on it, and what remains as charcoal is collected for use." What difference is there between this process and that by which we, in more enlightened days, convert our coal in Bengal into coke? It may be that the coal so converted bears but a small proportion to the total quantity raised; but taking it at only 500,000 tons a year, this means that some 250,000 tons of useful products are annually dissipated in smoke. And yet one of these products, the ammonia, when converted into the sulphate, is one of the most crying needs of India as a manure for sugar-growing. No doubt the high cost of this manure at present is the reason that it is not used by the sugar cultivator, but if all the ammonia now wasted on the coal-fields were converted into sulphate, there is not much doubt that the price in India would be so reduced that a demand for it would be created. It is ludicrous, at least it would be so if the tale were told about anyone but ourselves, to be told that all the sulphate of ammonia produced at the Giridih coke-ovens is exported to Java, whence it returns to India in the form of sugar, that undersells the native article. The want of cheap sulphuric acid in India is no doubt one of the reasons for the apathy shewn, but, if a demand for it arose, there is reason why it should not be supplied. And the ammonia is not the only bye-product concerned. Is there no demand for power on the coal-fields, that such an enormous source of energy as is contained in the gas produced in coke-making should be neglected?

Mr. H. G. Graves also dilated upon the waste of burning coke in heaps. Even in the outskirts of Calcutta it had been the custom to coke small quantities of coal in this way, with the very natural result that their already smoky atmosphere became still more polluted. The heaps were bigger in the colliery districts, where the waste was accordingly less in proportion, but it was, in any case, enormous; at least the annual production of one large colliery was dissipated and absolutely lost to them. The price of that 250,000 tons would go far towards building a big range of ovens. Ten plants, the size of those described by Mr. Ward, were required to deal with the coke production of India.

He remembered well the days in England, when there was such violent discussion as to the comparative merits of beehive and bye-product coke. That was now settled satisfactorily, and the result of English and German experience was at their disposal. It was only a very few years ago that the next great step was taken, the introduction of gas-engines run by waste gases from blast-furnaces and coke-ovens. That was now an accomplished fact, and gas-engines of huge size were being built by the dozen. In fact, it was often said that the bye-products were more important than the main product itself, and the proposal was seriously mooted that blast-furnaces should be built to produce gas with pig-iron as a bye-product. Of course, in India, there was the difficulty of obtaining capital and of overcoming inertia where a new departure had to be made. But there was the experience of England, Europe and America to draw upon, and he confidently looked forward to the time when waste would be considered almost criminal.

Mr. H. A. Pringle then read the following paper: "Notes on the Economics of Coal Mining in Bengal," the discussion of which was deferred until the next meeting.

Notes on the Economics of Coal Mining in Bengal.

BY

H. A. Pringle, M.I.M.M., F.G.S.

(*With Plates* 1—3.)

The writer would probably have felt some diffidence in writing authoritatively on the Indian coal industry and the methods of exploiting it as applied more particularly to Bengal and the Central Provinces, were it not that his extensive mining experience in various parts of the world, embracing both coal and metal mining, perhaps enables him to arrive at conclusions—largely by comparison where conditions are somewhat similar—rather sooner than might otherwise have been the case.

The degree of success attending any commercial enterprise—be it mining or industrial—is largely dependent on, and is more or less the reflexion of, the human instincts and characteristics of those controlling or influencing its destinies. Prosperity, on the one hand, comes to the well-ordered mind and mature judgment as a blessing to be reverenced and tended with all the care and skill of which human ingenuity is capable; then, should the tide turn and a period of adversity set in there is available a solid reserve of power with which to stem it and successfully withstand its encroachments. On the other hand, there is always the human element, be it individual or collective, to which affluence or large profits quickly and easily amassed is a novelty; the procedure in such cases probably gave rise to the old adage concerning the ultimate destination of the beggar-on-horseback.

So it is with industries, and especially the mining industry. In older established coal-mining centres alternating periods of prosperity and depression have left their mark in no unmistakable manner; the successful ones have been those that 'laid by' for the inevitable rainy day. The Bengal Coal boom of 1907-08—differing in no respects from other periods of unduly inflated prices—has also left its trail, and as the tide continues to ebb it leaves in its wake fresh exposures. Calamitous as this may appear to the individual, it nevertheless has its redeeming feature for the industry at large, as is evidenced on many sides by the earnest endeavour to benefit by past experience and to initiate a policy of reform and an improvement in the economic conditions under which the industry is being exploited. With the politic side of the position the commercial intelligence and the administrative abilities of the controlling agencies in Calcutta must deal, but the technical economic conditions are such that every Member of this Institute with any active control in the management of collieries must be constantly studying them in the endeavour to evolve what might perhaps be called the highest 'economical coefficient,' human or mechanical, in all things.

Prefatory to the subjects more exhaustively dealt with later on, the writer proposes to touch lightly on the question of 'standardisation.' Anything that makes for economy generally, or that bears the impress of economy, is deserving of serious and impartial consideration until such time as its local applicability fails to be established; and, broadly speaking, the standardising of machinery should be an engineering principle, as elastic in its abstract form or initial selection of plant and mechanical appliances, as it should be rigid in its concrete application to type and pattern. It must necessarily be approached from a free and generous standpoint; all sorts and conditions of machinery may be equally suitable for one given purpose according as the local or economic conditions dictate, for 'one man's meat is another man's poison' is metaphorically as true of mining as it is of humanity. The benefits accruing from a systematic and judicious standardisation and the general interchangeability of working parts are so obvious that it is hardly necessary to enumerate them. The stoppage of work because one simple mechanical part of a machine is lost, gets out of gear, or is broken and cannot be replaced without prolonged delay, is a contingency which at one time or another manifests itself to every manager of mechanically-operated concerns. Here, in Bengal, where groups of collieries are controlled from one commercial and secretarial centre, the conditions are eminently such that the principle can be applied with the maximum beneficial results.

It is no new conception ; in mechanical and metallurgical treatment of ores it is adopted by the most influential of controlling groups ; it probably finds the readiest response in countries where, by force of circumstances, machinery has to be imported largely and the profits of an undertaking become seriously jeopardised through a cessation of work caused by the inability of the management to replace locally—or without specially importing—spares and renewals. As an instance of the extent—beyond its mechanical aspect—to which the principle is carried, the most important gold-mining centres in Australia and South

Africa have, to the writer's knowledge,[1] instituted standard forms for the segregation of working costs and periodical returns so that greater uniformity may exist for the purpose of comparison; and in America,[2] as the outcome of a desire of the authorities in charge of the publications of the four national engineering societies to co-operate in standardising abbreviations, symbols, punctuations, etc., in technical papers, a representative committee was formed and the observance of a carefully devised set of rules was recommended.

In the following year[3] another paper on the same subject was read, the object of the paper being to bring about greater uniformity in specifications governing iron and steel generally; and again when the International Association for testing materials was organised at Zurich in 1895 a Committee was charged as follows:—

> 'On the basis of existing specifications to seek methods and means for the introduction of international specifications for testing and inspecting iron or steel of all kinds.'

What is desirable from an international standpoint is also advisable—one might almost say necessary—to the individual capitalist or coal company; and as the balance of power rests with the managing agents of the mining industry, it is sincerely to be hoped that writ large in their offices will be found the verb 'to standardise.'

The writer does not consider any apology necessary for making use of the standardisation principle as a preface to his subsequent remarks, because he deems it an eminently fit and proper prelude to the more prominent subjects now coming under review.

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1 Trans. Inst. of Min. & Metallurgy, Vol. XVIII.
2 Trans. Am. Inst. M. & E. Lake Superior Meeting 1904.
3 Trans. Am. Inst. M. & E. Atlantic City Meeting 1905.

HAULAGE.

The conditions affecting the underground transport of coal in India are more or less peculiar to the East and rarely met with elsewhere : the problem from the first has been, and still is, the blending of modern European ideas with the more crude but deeply grafted and popular indigenous methods. The writer has devoted much of his time to the elucidation of the question, and in presenting his ideas to the mining public seeks only the economic advancement of the industry from its engineering side. He is fully alive to the fact that in other countries where the labour conditions are totally different the system of haulage he now advocates as applicable in part to India would be ruled out as a retrogressive step, and rightly so too ; but the dominant feature 'labour' is accountable for many and strange vagaries in the industries of the world.

The mechanical haulage most in vogue throughout the Bengal coal fields is a form of the dip-engine-plane system, and perhaps the most striking feature about its use at the majority of the collieries is the disproportional capacity of the hauling plant to the daily output it hauls ; it is no exaggeration to say that the average hauling plant represents an unremunerative capital outlay for ten hours out of each twelve. This is more the fault of the system than the individual : the former has been stereotyped throughout the coal field. The majority of managers of collieries would gladly exchange it for a form of endless rope haulage with its continuous, slow moving units of load, delivering its burden—at a minimum of upkeep, repairs and renewals—with regularity throughout the whole day ; but there are many reasons why endless-rope tub-haulage, especially where the inclination of the seam is heavy, is unsuitable. The natural carrying unit of the native is a basket; physically the majority are unfitted to handle heavy tubs, especially on steep or varying grades; and at places where a main rope plane is fed from either side by successive galleries at descending intervals throughout its greater length, the attaching and detaching of tubs would offer considerable difficulty, and their manipulation would be beyond the power of the average native and his consort. To the writer, then, it appears that a fusion or merging of Eastern practice with Western ideas offers the soundest solution of the question; economic principles on the one hand have to be religiously observed, whilst native traditions and prejudice, on the other hand, must be equally respected if the greatest good has to result from the blend. On these lines the writer has proceeded.

Primarily, the system he advocates is an economical means of conveying tributary coal through the medium of an over-head single rail to the existing engine plane, the baskets of coal being suspended singly or in numbers by means of a 'carrier' running on the said rail: in this way it is contended that the individual will propel a larger quantity of coal with a less expenditure of physical energy than is ordinarily the case where the basket is carried on the head.

Secondarily, it is claimed that under many conditions the system can be applied throughout a colliery both for main engine planes as well as tributary galleries—the former being operated by ordinary endless-rope haulage, in which the full baskets travel in single units, or in 'sets' suspended from a single rail, and the empties return on a parallel rail, the intervals apart at which baskets or sets are attached being more or less uniform, but not arbitrarily so; the daily output desired is practically the determining factor for both the ' rope speed ' and the spacing of units. In such a colliery there would be no tubs or tram lines laid on the floor, and the ratio of live load to dead load would be as 8 to 1 in the new system and $2\frac{1}{2}$ to 1 in the tub haulage.

Haulage.

At this stage a clearer perception of the writer's ideas will be gathered from a study of the accompanying illustrations, which are intended to convey a wholesale idea of the system, and which if carefully studied will enlighten members on a multitude of points the explanation of which in letterpress would unduly prolong what already promises to be a more lengthy paper than the writer anticipated.

Claims and Comparisons.

1. The coal travels from the working faces to the screens without suffering the usual breakage inseparable from intermediate handling. The object of every producer is to turn out the largest percentage of round coal within economic possibility, and the proportion, whatever it may be, is governed by three conditions :—

(*a*) the natural structure of the coal itself,
(*b*) the method of working it at the face,
(*c*) the treatment it receives in transit ;

and according as it is of a soft or friable nature, as opposed to a harder or more homogeneous coal, will the normal proportion of ' round ' to ' slack ' vary, the more adverse proportion being accentuated when economic principles effecting (*b*) and (*c*) are neglected or partly disregarded. Not being for the moment interested in the hewing methods, let us take, as an every-day example of coal in transit, a

12 cwt. tub of coal—the average carrying unit of the Jharia field—and follow it along the ordinary pit track, the latter frequently clogged with dirt and coal, rarely uniform in its surface, the tub constantly jarred by buffering and oscillation, and the load the whole time tending to disintegrate its cubical units along their weaker planes by pressure and friction. Follow this tub of coal and witness its ultimate degradation : more often than not its contents are sided over and left to blister in the sun or soak in the rain : in either case the preliminary journey along rough tracks has tended to prepare the larger pieces for further sub-division on the least provocation. So much for the journey ; but what of the shattering effect and the loosening of fibres along weakened planes, of 20 baskets of coal being dumped one on top of the other into the tub before it starts on its journey until its complement of 12 cwt. is made up ? It is of course possible to argue that an extra 5 % of slack is not of much account, but this Institute was not founded to harbour principles so subversive of true economy and technical advancement. The relative disintegrating effect of the two systems leaves no doubt as to the economic balance being in favour of the new system. In this the baskets carry 1 cwt. and therefore only 12 have ultimately to be dumped at the screens, as compared with 20 to make up the 12 cwt. contents of the tub, and until the screens are reached the 1 cwt. unit is not disturbed ; the single rail is 4 feet off the ground, free from all the clogging debris unavoidable on the tram-line, and of a perfectly uniform surface ; and whatever treatment may be in store for the coal *after it leaves the basket*, it at any rate is fit and sound at that point and in the best possible condition to withstand rough usuage from there onwards.

2. Although the majority of coal seams afford ample height for 'carrying on the head,' there are some which do not provide head room, and where 'long carries' prevail in galleries it is not such a simple matter ; in such cases the single-rail basket-tramming is specially suitable as it can penetrate wherever a width of 2′ 0″ and a height of 3′ 6″ (or less if necessary) is available. It can be used as a single unit of one basket attached to one carrier, or four or more baskets attached to two or more carriers coupled, and therefore adaptable for long tramming distances from the face to the engine plane. Assuming the limit of carrying distance as now practised is 400 feet and a collier hews one ton per shift, his 'kamin' makes over 30 trips, along we will say a level course, with a basket holding say 70 lbs. of coal ; in doing so she covers a total distance of 24,000 feet or 8,000 yards, say 4½ miles. Let us apply this to a similar gallery where four baskets, each containing 112 lbs. of coal, are suspended to a carrier running on a single overhead rail ; *five trips* suffice to carry one ton, on a road—graded as all water-levels are graded—for the sake of argument 1 in 100 in favour of the load. *Five* trips as against *thirty!* In other words the 'kamin' could tram her spouse's ton of coal from a distance of 2,400 feet and deliver it on to the main engine plane at the same expense in energy as she formerly carried it 400 feet. The same principles as apply at a colliery in England where intermediate haulage is done by horses or ponies apply equally here, in that as the working faces advance 'ganin bords' or 'wagon ways' must be established to the exclusion of certain galleries, thereby liberating the single rail for use elsewhere—leaving only the props and cross pieces, so that when the pillars later on have to be worked out nothing

more is required to reinstate the track but to lay the single rail down again.

To carry this section to its logical conclusion it would appear that one main engine plane, centrally placed in a property having a total strike length of 4,800 feet, would suffice. It must not be here assumed that the writer is pledged to this view—for there are other considerations in the life of a colliery besides haulage—however important the latter may be.

Criticism is however cordially invited on this particular aspect of the case, because existing conditions throughout the coalfield are such that considerable economies could be effected, if a system were adopted admitting of easy and efficient hand-tramming over distances largely in excess of those now feasible; in this way the new system would be tributary to existing engine-plane haulage and would therefore come under its primary object.

3. Before continuing the comparison with other methods embracing the cost of upkeep, capital outlay, screening, and facilities for handling at surface, it is desirable, in order to do justice to the system, to refer to its general flexibility. Ordinary underground haulage includes at least three well-known methods, and the system under notice is equally adaptable, but on a smaller scale; for, be it remembered, the whole essence of this paper is the merging of methods; as well compare the massive shire horse of England to the dimunitive 'countrybred' of Bengal as seek to establish a close relationship between the appliances of a 2,000 tons a day pit and a 200 tons a day one.

Lighter ropes, engines and appliances generally suffice; as a unit of flexibility the basket or 'basket set' is incomparable—the nearest approach to the 'basket set' is the 6 cwt. loads prevailing in certain collieries in England. We have to take into consideration the human element and the part it plays in the manipulation of any ' system ' or ' individual units ' of a system. As a case in point and apart rather from its economic side take the position of employees working or travelling on, or crossing a main dip engine plane where tubs in sets of five to ten are running at comparatively high speed, and contrast it with the same employees on an endless-rope basket-haulage plane where suspended baskets, singly or in sets, are moving at a speed not exceeding 100 feet per minute—a little more than one mile per hour—spaced on the rope at intervals of say 60 feet. It almost resolves itself into a case of ' fraught with danger ' versus ' freedom from risk.' Critics of the newer haulage may well pause and reflect that if the new method does not commend itself at first sight, it at least has the merit of elasticity ; and, if the local conditions or customs do not entirely favour it, there is always the alternative and broader-minded policy of modifying existing conditions, so that the flexibility of a haulage innovation finds sympathetic echo in a generously modified working policy, the ultimate result of which is that the mutual desire to effect a common economic end is fully achieved.

4. Having endeavoured to show its applicability and general adaptability, in which connection the illustrations will serve a useful purpose, let us now consider it from a capital expenditure standpoint ; intimately associated with the latter is the cost of screening plant, superstructures, etc. For purposes of comparison the writer will ask his critics to keep in mind the prominent haulage and mechanical features of a colliery producing an average output of 300 tons per day for 25 days in the month. Such an out-

put involves a larger daily turnover than 300 tons on at least three days in each week—probably on such days it would average 400 tons; at any rate the hauling power and rolling stock of the colliery should be able to handle daily at least the latter quantity. Assuming there are two main inclines each 1500 feet long, the chief item of expenditure is in the one case tubs and heavier rails, in the other case baskets and carriers.

Two Inclines.		Two Inclines.
Tub Haulage.		*Basket Haulage.*
Tub 400 @ 100 = Rs. 40,000		3 Wheel-carriers 100 @ 20 = Rs. 2,000
		Baskets 8000 @ -/12 - = ,, 6,000
		Gallery carriers 400 @ 10 = ,, 4,000
Rs. 40,000	Against	Rs. 12,000

It is not within the scope of this paper to go elaborately into the dozen and one minor details, nor do they appreciably affect the main issue; *e.g.*, the total cost of the single large-diameter rope and the tramline laid with 18-lb. rails, though perhaps not greatly in excess of the cost of the double length of smaller diameter rope, return tension wheel, uprights, and overhead track of 10-lb rails, is however sufficiently so to justify a decided pronouncement in favour of the basket system. With regard to tributary lines the simplest way of viewing the comparison is to remember that 400 feet is the limit of carrying distance, and as that limit is approached the tub haulage has to be extended. Looked at in this way it focuses the extra cost of the single rail in tributary galleries to a fine point; at least two working faces, *viz.*, a 'bord' and its 'stenton', contribute to the output of one gallery, and, assuming each working face in the pit yields one ton, and only one shift per 24 hours is worked, the following formula should represent the case:—

$\frac{\text{Number of working faces}}{2} \times 400$ = additional length of single-rail track: $\frac{\text{tons per shift}}{2} \times 400$ will give the same result. Therefore an output of 400 tons per shift requires $200 \times 400 =$ 80,000 feet of single 10-lb. rail, approximately 120 tons, equivalent to a capital outlay of about 14,000 rupees. At first sight this would appear to bring the relative costs to 40,000 rupees for the present practice and 28,000 rupees for the basket method; but, on closer examination, the tramway extensions hitherto regarded as equivalent in cost to the single rail up to the carrying limits (*i.e.*, within 400 feet of working faces) consists of 2 rails of 14 or 16 lbs. per yard each, as against 1 rail of 10 lbs. per yard, or say 30 lbs. to 10 lbs. per yard over the neutral section: this difference of 20 lbs. per yard more than counterbalances the extra cost of the single-rail inbye extensions. The two plans A and B will perhaps assist in making this point clear. They do not represent the conditions of work at any known colliery, but are more or less typical of systems of work, produced here for the purpose only of comparison.

So far we have dealt broadly with the prime cost of the rolling stock and permanent way. We now pass on to capital expenditure on surface plant—superstructure, screening appliances, etc.

It must be obvious to all that a superstructure to withstand the heavy vibration and shock of tubs carrying 12 cwt. of coal, or a gross load of 16 to 17 cwt. passing over it and being tipped on it, requires heavier framework and greater stability all through than one which has only to handle units of a total gross weight of about 120 lbs.

Similarly a hauling engine bringing 5 to 10 loaded tubs at a time up an inclined plane and working very intermittently throughout the day—at a comparatively high rope speed—must be of much greater horse-power and more massive build than a slow-running continuous-working endless-rope engine distributing its aggregate load over a whole day. It may perhaps be argued that the local labour conditions are such that it is necessary at times to be able to raise a full day's output in two or three hours—in which case the heavier engines are indispensable. This is quite true of tub haulage and only appears to strengthen the writer's plea for a less expensive and more flexible carrying unit. One tub represents Rs. 100, and for this sum a colliery could be provided with 133 baskets or, to carry the hypothesis a stage further, the collier would have a coal standage of over 6 tons as against 12 cwt. The argument is hypothetical of course, but it serves to illustrate the point from a capital outlay view. A further advantage and one of much importance in many cases is the ability of the same engine to work one or more subsidiary haulage-planes either on the surface or underground; especially is this a useful feature on the surface where the handling of wagons and smaller units can be mechanically arranged under the one supervision by means of a second endless rope.

In collieries where the quantity of water is not excessive and gravitates to the bottom of the main dip, a simple rope attachment to the return wheel is all that is necessary to provide power to a pump for handling such water.

Upkeep.

5. Here again, as in the preceding section, the path seems fairly clear; the general principle, *i.e.*, its appli-

cability to local conditions, being admitted, the cost of maintenance is so obviously in favour of the lighter plant and rolling stock and continuous slow speed system that special comment is unnecessary. One point may perhaps be brought well to the front, *viz.*, the immunity from serious damage should any breakaway or accident happen on the engine plane. Every one knows the disastrous consequences resultant on a broken coupling or derailment on a one in four grade, when a whole or part of a set may run back into the pit and be practically annihilated or otherwise suffer material damage. The writer would merely ask what is the worst that can happen under the basket haulage apart from the breaking of a rope, a contingency common to both systems—a dropped basket or even a set of 6 baskets breaking loose and running back on the incline! And what the damage? Spilled coal, a few hundred pounds in weight; perhaps a broken basket or two, a few annas' worth. The three-wheel carrier being for the most part of wrought-iron would not suffer; in fact there is nothing about it that can take much harm, and if it were obliterated entirely it only represents a trifling sum as compared to the cost of a tub.

6. It will be observed that the carrying unit has throughout been represented as a basket containing 1 cwt. of coal, or a group of baskets six in number with a total net carrying capacity of 6 cwts. This standard has not been arbitrarily fixed and smaller baskets can be used; but the ultimate object should be to carry the greatest weight of coal in the smallest and lightest compass consistent with the handling ability of the native worker. This brings us to the consideration of relative proportion of live to dead load, and herein lies a feature which in the economic ethics of transport is too frequently disregarded.

The carrying vessel, whatever it may be, has two functions to perform :—

(*a*) To hold its load safely during outbye transit.

(*b*) To get back to the loading point inbye as cheaply as possible.

A tub carries from 10 to 12 cwt. of coal and when empty weighs 4 to 5 cwt. A basket set of six carries 6 cwts. of coal and when empty weighs, including carrier and baskets, about 80 lbs. ; say 3/4 of a cwt. consisting of 7 detachable units. The net working result on an output of 400 tons a day is that, under existing methods, 400 tons of coal involves a total load of 566 tons being hauled outbye and a dead weight of 166 tons being returned to the mine. Under the basket system the total load becomes 450 tons and the returned dead weight only 50 tons—the ratio of coal to vehicle being :—

$2\frac{1}{2}$ to 1 where tubs are used.

8 to 1 where baskets only are used.

Screening facilities.

7. Under this section the new system offers considerable attractions ; its flexibility is perhaps seen at its best ; by raising the full road cross arm on each support, or by increasing the height of the support at the outbye end of the incline as the surface is approached, sufficient height can be obtained to self-gravitate the full carriers to the screens, and the empties back again to the incline. Practically no handling or labour is necessary, and as each basket passes over the screen on which it is to empty its contents, one of the supporting loops connecting it to the carrier is slightly raised and detached from the hook ; the basket then deposits its load on to the screen, remaining suspended by

the second supporting loop to the carrier, and so passes on, still by gravitation, to the empty road without having been stopped. Dirt, slate and inferior coal picked out on the screens and put into baskets have access to the same circuitous rail track, and can be dumped at will before the returning baskets again come under the guidance of the endless rope and re-enter the mine, or can be taken back (without being emptied) into the mine and used for pack building, stowing, etc , should the method of working necessitate such material.

8. In closing this section of his notes the writer wishes to emphasise the fact that the 'basket haulage system' as now put before the Members of this Institute should be studied from two primary aspects :—

1. Its applicability as a whole.
2. Its applicability in part.

The probability is that only in new collieries or in newly opened inclines can its adoption as a whole be prudently counselled. The depressed condition of the industry and the natural conservatism of a large community which has hitherto been content with existing methods—and perhaps quite rightly so, when one remembers the big profits that have in the past accrued through them—are factors to be considered; and, although depression may at any time give place to prosperity, inherent conservatism of too intense a nature can only be converted to other and newer methods by the actual results of comprehensive experience. This latter is to be had at very moderate outlay at any colliery by experimenting with any two or three contiguous galleries where the 'carry' to the tubway is becoming too burdensome.

For the means of establishing the practical proof of its applicability as a whole the writer is indebted to Messrs.

Shaw Wallace & Co., who placed one of their inclines at his disposal and generously financed the first experimental engine plane throughout its construction: through their courtesy the mining public is cordially invited to examine for itself the system in actual operation. To Mr. Thomas Emmerson, the Manager of the Colliery, where the experimental plant is in operation, and to Mr. Thomas Fishwick, who, as Mechanical Engineer for Shaw Wallace & Co., has supervised the construction generally, the writer's thanks are also due.

The writer had hoped to have been able to embody in this paper a description of his 'Basket Winding' system for adoption in shallow shafts; but the experimental work in connection with this innovation has been unavoidably delayed. He hopes, however, at an early date to place the results of his experiments before this Institute.

The meeting closed with a vote of thanks to the Asiatic Society for the loan of their rooms, proposed by Mr. Pringle and seconded by Mr. G. F. Adams.

The Annual Dinner.

The Annual Dinner of the Institute was held at the Volunteer Headquarters, Calcutta, the President, Mr. Heslop, taking the chair. The members present were:—

Mr. S. Heslop; Mr. Thos. Adamson; Mr. R. P. Ashton; Mr. A. A. Agabeg; Mr. C. T. Ambler; Mr. G. F. Adams; Mr. R. J. Browne; Mr. F. S. Benson; Mr. R. Barrowman; Mr. H. Brown; Mr. T. Chrystle; Mr. Geo. Dixon; Mr. H. G. Fleury; Mr. B. S. Field; Mr. L. L. Fermor; Mr. H. G. Graves; Mr. W. J. Greener; Mr. W. T. Griffiths; Mr. Glen George; Mr. G. H. Greenwell; Mr. F. C. Hughes; Mr. B. Heaton; Mr. J. S. Kean; Mr. G. C. Leach; Mr. F. A. S. Longley; Mr. T. D. LaTouche; Mr. Rob. Mitchell; Mr. Jas. Mackintosh; Mr. Geo. Miller: Mr. A. Mackay; Mr. S. McMurtrie; Mr. J. A. Millar; Mr. J. W. Nierses; Mr. F. Owen; Mr. C. L. Phillipps; Mr. T. C. Piggford; Mr. G. N. A. Pitt; Mr. H. A. Pringle; Mr. A. Russell; Mr. A. T. Rose; Mr. F. H. Robinson; Mr. W. J. Rees; Mr. F. M. Short; Mr. G. F. Scott; Mr. H. T. Thomson; Mr. J. J. Turnbull; Mr. J. Thomas; Mr. H. Walker; Mr. D. A. Whyte; Mr. C. L. Watson: Mr. J. R. R. Wilson; Mr. A. Whyte.

The guests of the Institute amongst whom were the leading representatives of Revenue, Railways, Mining, Journalism, were:—

The Hon'ble Mr. R. W. Carlyle; Mr. E. Digby; Mr. D. J. Macpherson; Mr. J. A. Marshall; Mr. Phil F. Ryan; Sir T. R. Wynne; Mr. Phil Knight; Mr. W. A. Lee.

The guests introduced by members numbered about 22.

At the close of the dinner, after the usual loyal toasts of "The King" and "The Viceroy" had been duly honoured, the President proposed "The Mineral Industries of India." He said:—

GENTLEMEN,—I have the pleasure of proposing the all-important toast of the Mineral Industries of India. This is a far-reaching subject: the minerals of India occupy a country extending over thousands of miles. From the broad base of the Himalayan Mountains to the Southern point of India, from the shores of the Arabian Sea to the land of the Pagodas, there exists a vast store of mineral wealth of great diversity of character.

Minerals have been known to exist from the earliest times, for have we not evidence of it from its iron smelting that existed all over the land, its gold washings in the river sands, its ancient Arts and Manufactures, and from the writings of Pliny, of Megasthenes, and other ancient writers of 2000 years and more ago? The working of this great store of mineral wealth is growing in importance year by year, and shews a constantly increasing development of the mineral industries of India.

The working of the mineral coal, with which I have been directly associated during many years in India, has been in operation for more than a century, but its development and progress was at first but slow, for up to 50 years ago it had only reached the total of about half a million tons, but with the advent of Railways a few years before, it had been gaining a sure and lasting footing, and it went on increasing with their extension, the one expanding with the other. Twenty years ago the output had reached two million tons. Ten years ago it had advanced to five millions, since when its expansion has been great and rapid, the output having now reached considerably over 12 million tons. But what may not the possibilities of the future of Indian mining be, for who would have believed it would have shewn in the past decade an increase greater than in all the years preceding it. We cannot perhaps imagine that the Indian industry will ever attain to anything like such magnitude as that of Great Britain or the United States, but I do believe that in the course of time, Indian mining will have reached such a stage of development, that the present output will be considered a comparatively small one, for I have every confidence in a great and prosperous future for the coal mining industry of India

In giving you the toast of the mineral industries of India, I have much pleasure in coupling with it the name of Mr. Lee, Chairman of the Indian Mining Association.

In replying to the toast, Mr. W. A. Lee said:—

When I received an invitation from your Council to dine here to-night, I thought that as I was only a guest, this was an occasion when I would have nothing to do but enjoy myself, but a few days ago I was asked to respond to this toast. I said that it would be better if this reply were in the hands of a more competent speaker, and I hoped that it would then be all right from my point of view as far as I was concerned. Consequently, I have not prepared and you will not be treated to a great quantity of those highly interesting statistics with which it is customary to adorn a speech upon such a subject. The temptation to use statistics on such an occasion is very attractive, they are so very convenient, they fill up a good deal of time to recite, and then they can be made to support any argument, and the more complex the subject the more convincingly can a given set of figures be employed to demonstrate the correctness of the most diverse opinions.

We frequently hear it said that India is a poor country, and in nothing is it more true than with reference to minerals. In comparison with its size India is in most respects a poor country, and although its minerals, as yet largely untouched, represent enormous wealth, when that wealth is considered as spread over a million square miles it seems somewhat thinned out. Considering that India is nine times as large as the United Kingdom, the minerals of India do not compare with the mineral wealth of the old country.

There is more than twenty times as much coal mined in Great Britain as in India, and twenty-five times as much of other minerals.

The mineral wealth of a country is not capable of expansion in any way, in the same manner as for instance agricultural wealth by improved methods of working: mineral wealth is a fixed asset, and once dissipated is gone for ever. A nation which mines its minerals and exports them may be likened with considerable truth to a man living on his capital, which in an individual is generally understood to be a thriftless proceeding, and although this consumption of capital is inevitable if the minerals are mined, it is of the very first importance that the country should get out of the minerals all the economic benefit that can be obtained. Minerals should be mined in the most efficient manner to ensure that their winning entails no unnecessary cost to the community, and to ensure that the methods employed shall be such that the minerals remaining in the ground shall not be lessened in value nor made more difficult to win.

After that, the products of the mines should be so used in processes of manufacture as to return to the community the maximum amount of benefit.

At the moment, the mineral wealth of this country is being squandered by ores being exported instead of being reduced in the country, and the resulting metals either exported or employed in manufactures within our own borders. One of the most flagrant examples is that of manganese, hundreds of thousands of tons of the ore being sent out of India every year, and none of it is used here in the production of metals.

We have also for example bauxite, and some of it has been mined, but I have not seen any proposals for the manufacture of aluminium.

This phase will doubtless pass, and a more efficient generation will not permit wealth to leave the country in the shape of raw material which can with profit be manufactured here and a more valuable product obtained for export or for home consumption.

The Government of the country is gradually awakening to a more complete sense of its responsibilities as custodian of the rights of the community in respect to the minerals in the country, and the new rules framed a year ago for the working of minerals on Government land show much appreciation of the need for considering the requirements of the country in the disposal of minerals.

Coal, as well as other things, only exists in India in very limited tracts, and coal is a necessity in all industrial enterprise except only agriculture, and the nation without coal will necessarily fall behind. Some day, one or two centuries hence, coal will have been exhausted in most countries, and will remain only in the hands of perhaps one nation. When that day comes, the nation which alone has conserved its store of fuel, its store of energy, will rule the world.

While it is true that none of us came to India solely for the benefit of our health, we may not forget that the mineral wealth of this land is very largely committed to our hands, that we are trustees of this great wealth of such incalculable importance to the country, and it behoves us so to deal with our charge that our operations may attain the utmost efficiency and may not squander any of the wealth we hold in trust, so that those who come after us may not be able to point the finger of scorn and say: 'Here is an 'enemy of the human race, this man wasted and destroyed 'the energy which in past ages was stored up and made 'available for the benefit of mankind.'

Sir, we, who are engaged in the mineral industries, realise, every one of us, our responsibility to the country which shelters us, and we strive always without ceasing, and often in the face of great difficulties and mountainous obstacles, for that efficiency which our ideal places before us but which our hands may not achieve.

The work done by this Institute for the benefit of the mineral industries is not to be easily gauged. By leading us to inform ourselves and each other it helps us towards a larger measure of efficiency, and enables us better and better to do our duty to ourselves, to the mineral industry for which we labour, and to the land we live in.

The remaining toasts were "The Guests," proposed by Mr. T. H. D. LaTouche, to which the Hon. Mr. Carlyle replied; and "The New President" Mr. S. Heslop, proposed by Mr. H. G. Graves.

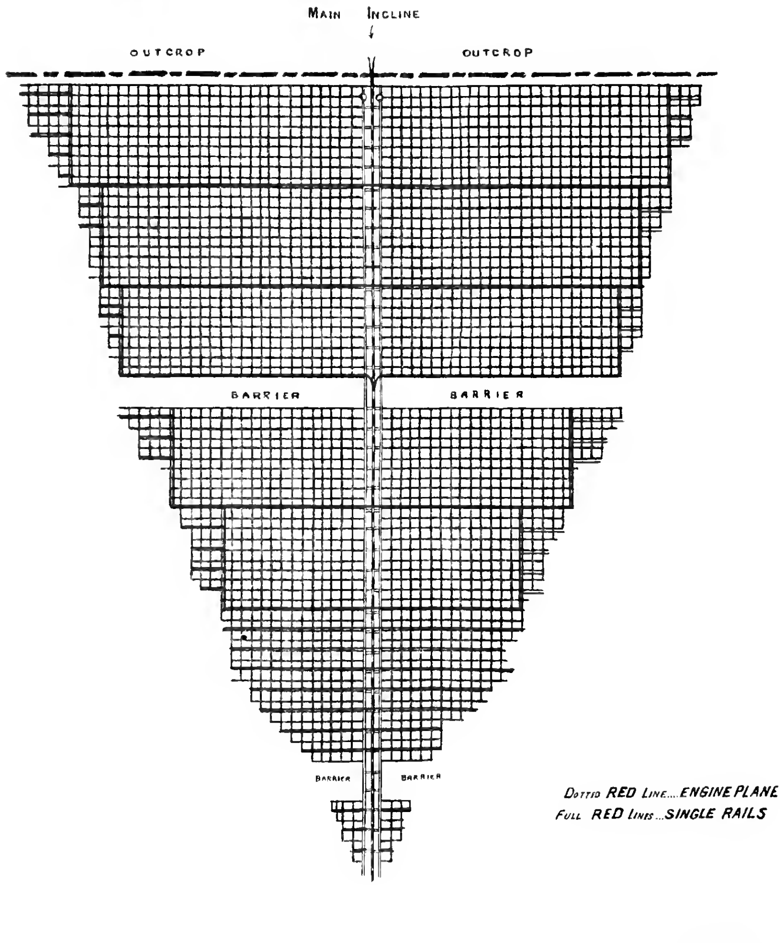
EXCURSION.

On Saturday morning, several of the members of the Institute visited the geological galleries of the Indian Museum, round which they were conducted by Mr. LaTouche assisted by several members of the Geological Survey. Attention was directed specially to the Indian precious stones, Deccan Trap zeolites, Brazilian monazite, C.P. bauxites, Kishengarh sodalite-bearing rocks, scratched pebbles from the Talchir beds, marbles, manganese-ores and minerals, meteorites, and some of the Siwalik fossils.

After a very interesting time spent in examining these collections, a few members still had sufficient energy left to go upstairs to the palaeontological gallery, where they were shewn ammonites and Gondwana plants.

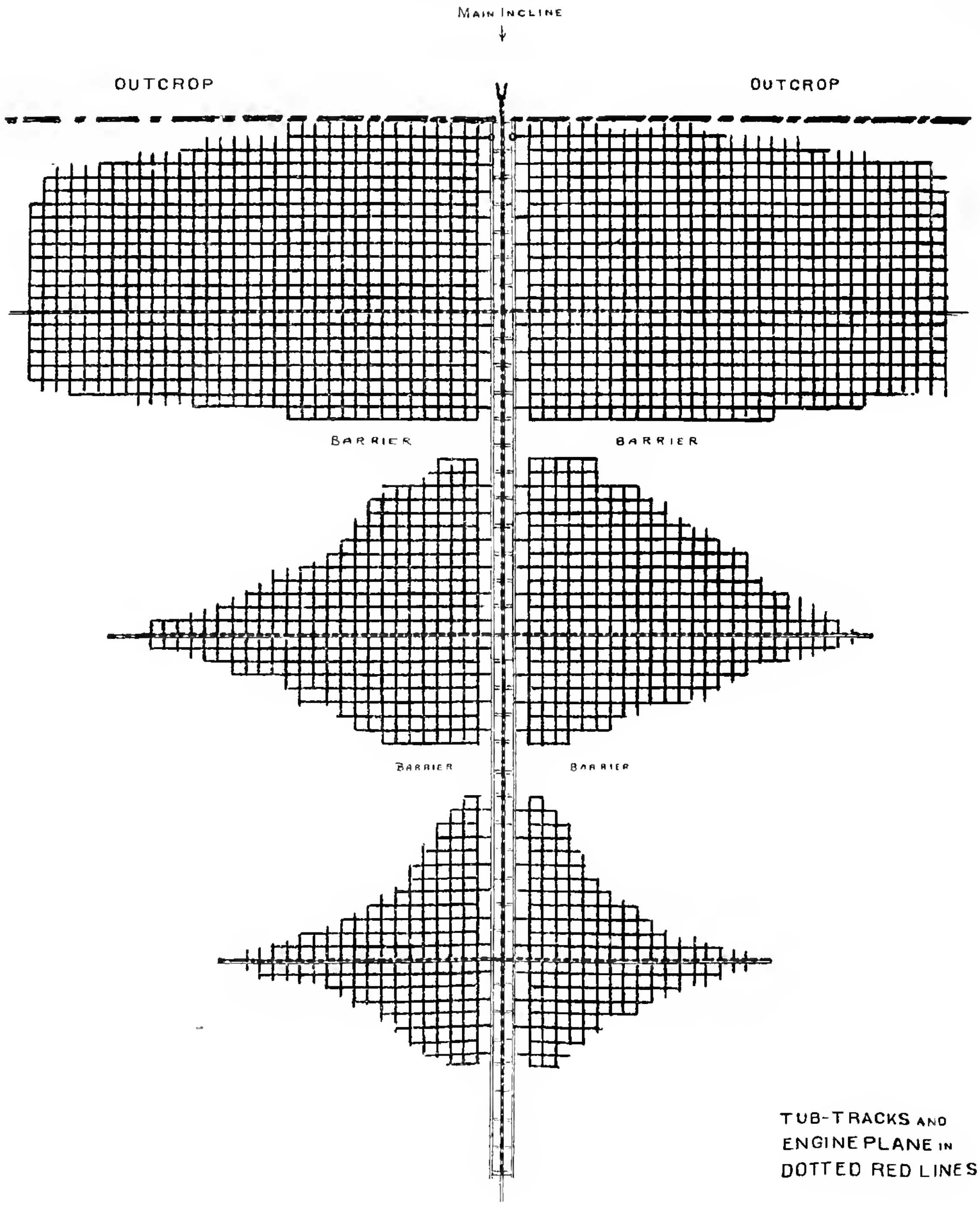
GARDEN PARTY.

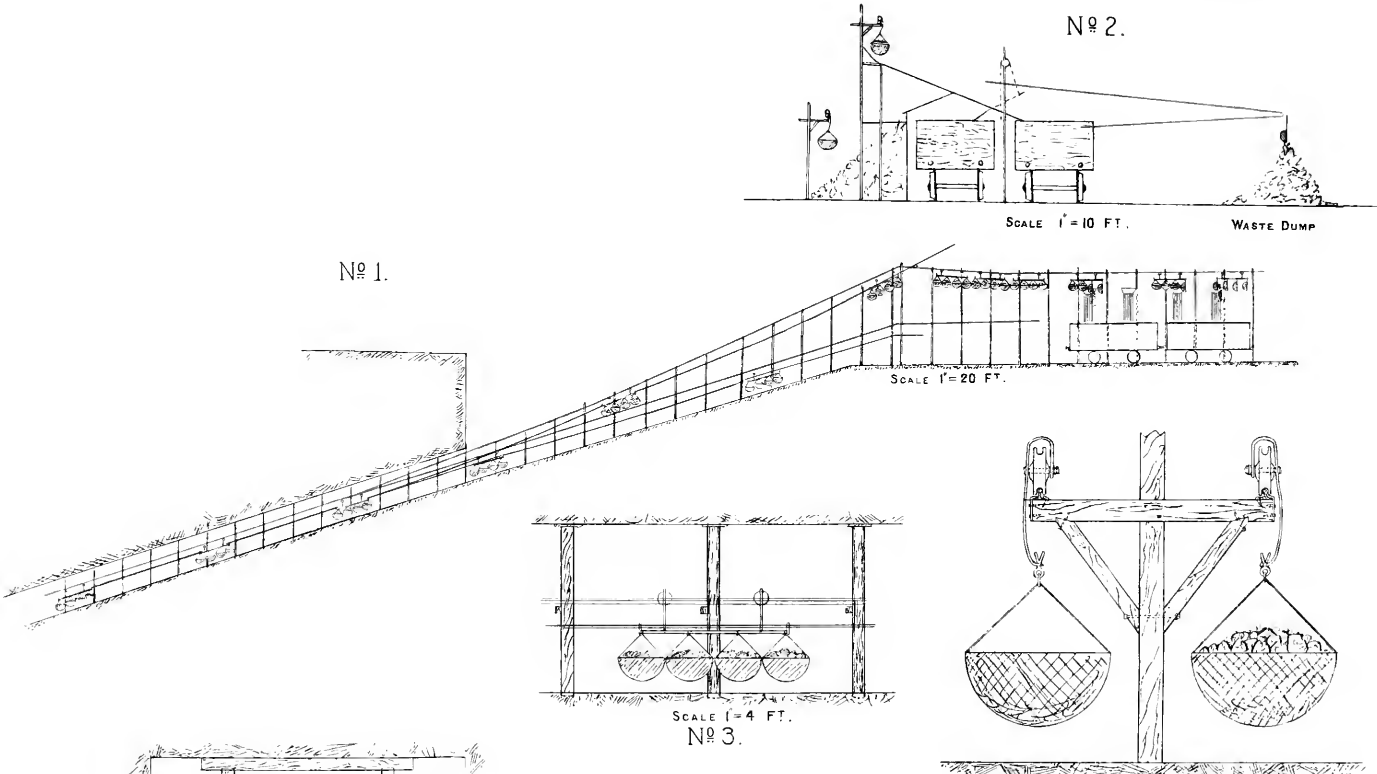
In the afternoon a garden party was given at 21, Belvedere Road, Alipore, by the Hon'ble Mr. Justice and Mrs. T. W. Richardson and Mr. R. P. Ashton. In addition to a good attendance of members of the Institute and their lady friends, the occasion was honoured with the presence of H. H the Lieutenant-Governor, Sir Edward and Lady Baker, Sir T. R. Wynne, Mr. Noel Paton, and the Hon'ble Mr. H. E. E. Proctor. Besides tea and tennis, the entertainment included some excellent vocal and pianoforte renderings. The heartiest thanks of the Institute are due to our hosts for their cordial hospitality and a most enjoyable afternoon.


Main Incline
Outcrop
Outcrop
Barrier
Barrier
Barrier
Barrier
Dotted RED Line.... ENGINE PLANE
Full RED Lines... SINGLE RAILS

H. A. PRINGLE. Notes on the Economics of Coal Mining in Bengal.

Transactions, Vol. V, Pl. 2.





№ 2.

Scale 1" = 10 FT.

Waste Dump

№ 1.

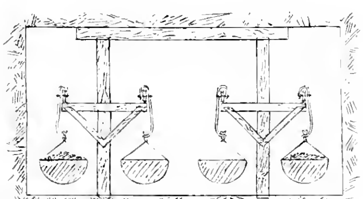
Scale 1" = 20 FT.

Scale 1" = 4 FT.

№ 3.

Scale 1" = 1½ FT.

№ 4.



Scale 1" = 4 FT.

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Transactions
of the
Mining and Geological Institute of India.

Part 2.] 1910 [October.

Meeting at Jherria.

Monday, the 7th March, 1910.

On the 7th of March, 1910, a general meeting of the Institute was held at the Jherria Club, combined with an excursion to the Sudamdih colliery by kind invitation of Messrs. N. C. Sircar & Sons, who also entertained the members at breakfast.

Special carriages were attached to the 22.18 train from Howrah on Sunday night and taken through to Jherria, where they arrived on Monday morning, and were formed into a special train to Pathurdihi near the colliery. The members assembled at the Sudamdih Coal Co.'s colliery at about 9 o'clock, and were shown the new electric installation, consisting of a central power-house, haulage gear, and electric pumps. Some of the more energetic members descended one of the inclines to inspect the electric pumps. The following is a description of the electric installation by Mr. T. Gibson, Manager of the colliery :—

DESCRIPTION OF ELECTRICAL INSTALLATION, SUDAMDIH COLLIERY, SUDAMDIH COAL COMPANY, LIMITED.

General.—Two Lancashire boilers are in use, for supplying steam to two sets of "Robey horizontal coupled compound engines," each of which drives its own generator, through rope-driving medium.

From the main switch-board, three overhead, bare cable transmission lines are laid, to three separate inclines. At two of the inclines, current is used for hauling and pumping; at the third incline, for pumping only. A little lighting is done at each of the inclines.

The hauling gears are similar in design and size, and provided with main switch, automatic circuit breaker and liquid starting switch, on their own switch-board. From the hauling gear switch-board, current is carried underground to the pumps, by heavily insulated and steel armoured cables.

Four pumps are fitted, three at present being in use. The pumps are all of the same type, three-throw type, but in two sizes, two pumps of each size.

The combined power of the two generating sets is 300 K. W. and is sufficient to allow for extensions, of another hauling gear, and as many pumps as will be required.

CENTRAL POWER HOUSE.

Lancashire boilers.—Two dish-ended boilers, 30 feet long × 8 feet diameter, flues 3′2″ diameter; made by Messrs. H. and T. Danks, Netherton; each boiler is fitted with the following mountings:—

One 6″ diameter junction stop valve, provided with perforated anti-priming pipe.

One compound safety valve, to blow off, for high steam pressure, or low water.
One dead-weight safety valve.
One check feed-water valve.
One blow-off cock.
One steam pressure gauge.
Two sets water gauges with shields.
Two fusible plugs.
Working pressure of boilers 120 lbs. per square inch.
Two vertical boiler feed pumps, Woodeson's patent, each capable of supplying 2680 gallons per hour.

Engines.—Two pairs of engines of same design and size, being horizontal, coupled, cross compound type.

Each cylinder is steam jacketed; diameter of high pressure being 14¼″, and that of low pressure cylinder 23½″, length of stroke 33″.

Automatic steam and exhaust valve gear, with valves of double beat type, is fitted. The valves are lifted and released by trip levers actuated by eccentrics, driven from a horizontal shaft, running from gearing off the crank shaft. The steam valves are placed on the top of cylinders, and exhaust valves at the bottom. Each cylinder is also fitted with automatic relief valves.

A governor fitted on the high pressure cylinder automatically controls supply of steam, against varying loads, and ensures a more or less uniform speed.

The flywheel is 16 feet diameter, turned and grooved for twelve ropes; a similar rope wheel, 3 feet diameter, is fitted on main shaft of the dynamos; length of rope drive 25 feet centres.

A tail rod is fixed on the low pressure cylinders, with a view to working condensers at some future date.

Generators.—Two continuous current generators of equal output and similar design, made by Messrs. E. Scott Mountain and Co.

Each machine is as follows :—

Number of poles ..	6
Total output	150 K. W.
Current	300 Amperes.
Voltage	500 Volts.
Horse power	200.

The brush gear consists of 6 brush holders, fitted to a movable ring for adjustment; each holder carries three carbon brushes, making eighteen brushes to each generator.

Main switch-board consists of marble panels with perforated metal ends, and lock-up doors; at present there are—

2 Generator panels.
1 Earth panel.
1 Distribution panel.
2 Spare generator panels.
1 Spare distribution panel.

Each generator panel is fitted with ammeter, voltmeter, single pole mainswitch, shunt regulator and equalising switches and automatic overload circuit breaker.

On the earth panel are one switch with wire and earth plate, and one fault detector.

On the distribution panel are three double pole switches, and three ammeters, one for each of the transmission lines.

In the power-house are two overhead travelling cranes, one over the engines, and the other over the generators.

Transmission lines.—At each end of the three transmission lines, the bare cables are connected to suitable lightning arrestors. Where the mains enter the power and engine-houses, heavily insulated cables are used.

HAULING GEARS.

Switch-boards.—These are fitted with double pole switch, and automatic overload and no volt release circuit breaker. A separate panel has suitable switches for underground supply.

Motors.—

Number of poles	6.
Output	200 to 300 H. P. (intermittent).

Both are of the same design, and of similar construction to that of the generators. They are controlled by a liquid (water) starting switch.

Hauling drums.—These are driven by rope gearing, ten ropes, from the motors, length of drive being 20 feet centres. The flywheel shaft is fitted with small brake wheel, the brake being actuated by foot lever. The drum which is on the second motion shaft is actuated by gear wheels from the fly-wheel shaft and has two brake rims attached, each rim being provided with two brake blocks, that is four brake blocks to each drum, all being actuated by the same foot lever.

The drum is loose running, being brought into action with a friction clutch, by means of a slow motion screw, worked by a hand wheel.

The hauling rope speed is six miles per hour, with a load of fifteen full tubs, on an inclination of 1 in $2\frac{1}{2}$.

The hauling gears are made by Messrs. E. Scott Mountain and Co.

ELECTRIC PUMPS.

All are of three-throw single acting type, but are of two sizes.

The larger sized pump is of 6/7,000 gallons per hour capacity, against a vertical head of 500 feet. The motor is 25 H P.

The smaller pump is about 2,000 gallons per hour capacity, against a vertical head of 300 feet; motor being 5 H. P.

In each case the pump and motor is mounted on a girder bed plate, which is fitted with trolley wheels to the gauge of the tramway.

All the pumps are similar in construction, fitted with ammeter, voltmeter, double pole switch and starting switch. The rams of pumps are worked from a third motion shaft, helical gearing being used.

At 11 o'clock the special train left Pathurdihi for the Standard Coal Co.'s siding at Benihar near the Jherria Club.

Here the members were entertained very hospitably at breakfast by the Directors of the Sudamdih Coal Co., Ld. The following is the list of gentlemen, 86 in all, who sat down to breakfast:—

Messrs. J. B. Argyle, C. T. Ambler, D. A. Anderson, G. F. Adams, Thos. Adamson, R. Aitken, M. J. Adamson, R. F. Augier, W. Augier, Harry Brown, A. C. Bull, R. Barrowman, D. Blair, J. W. Bulman, F. S. Benson, J. R. Bertram, R. G. M. Bathgate, J. A. Bayne, H. Chambers, Thos. Chrystle, D. Davies, W. E. Elphinstone, Dr. L. L. Fermor, Messrs. B. S. Field, H. G. Fleury, A. Gillespie, W. J. Greener, W. T. Griffiths, Glen George, H. G. Graves, T. S. Gibson, J. G. Herriotts, S. Heslop, F. W. Heilgers, Major F. C. Hughes, Messrs W. Hullock, A. G. Higby, J. S. Kean, J. Knox, Chas. Lea, G. C. Leach, A. G. Mackay, T. C. Murray, W. McFarlane, Geo. Miller, G. K. Mitchell, T. Morrison, W. Miller, J. J. Marshall, J. Miller, C. H. McCale, M. Munroe, W. A. Miller, F. Miller, Rob. Mitchell, W. O. Mitchell, C. Nairne, J. W. Nierses, E. D. Onraet, Joseph Parker, T. C. Piggford, G. N. A. Pitt, R. Purdy, C. Rayman, J. H. Rayneau, W. J. Rees, E. H. Roberton, A. Rose, J. Rose, A. Russell, F. M. Short, R. R. Simpson, E. G. Slater, Angelo Sundle, E. A. S. Tarlton, J. Thomas, J. J. Thompson, W. J. Thornton, J. J. Turnbull, H. Walker, Thos. Walsh, C. L. Watson, D. A. Whyte, F. Powell Williams, A. D. Wilson, and J. R. R. Wilson.

Mr. A. D. Wilson, Chairman of the Sudamdih Coal Co., presided. When breakfast was finished, Messrs. N. C. Sircar and N. M. Chaudhuri of the firm of Messrs. Sircar & Sons, and several others of our Indian friends joined the assembly.

In proposing the toast of the day, The Sudamdih Coal Co., Mr. Heslop said :—

GENTLEMEN,— I have very much pleasure in proposing the toast of the Sudamdih Coal Company, and in expressing the thanks of the Members of the Mining and Geological Institute of India to the Directors of the Company, for their very great kindness in inviting us to see their Sudamdih Colliery today, and to Messrs. Sircar & Sons for the excellent luncheon they have just provided us. Our thanks are also due to Mr. Gibson, the Manager, and to all concerned, for all the trouble and pains they have taken in showing us the Colliery and its splendid plant. I know, Gentlemen, I am voicing the feelings of all present when I say we have spent a most enjoyable and instructive day. Not only have we seen a complete and excellent electrical installation with powerful haulages, to meet the excessive dips that have confronted the management; but we have also seen in these high dips, and in the wonderful coal formations, one of the most interesting geological studies to be seen in this most interesting coal field. These fine thick seams have no doubt been the result of enormous accumulations of vegetable matter, showing the great abundance and luxuriance of plant-life that had existed in those periods of the past, the growth of which, with the subsequent process of formation into peat, and thence into coal, with its overlying rocks, having occupied long ages of time.

Messrs. Sircar & Sons are to be congratulated for their enterprise in being the pioneers of the introduction of electricity on a large and complete scale into the Jherria Coal Field; and I venture to predict, it is only the beginning of more to come, and that before many years are past, we shall see its use greatly extended, and for the inevitably greater depths and deeper mining of the future, universally adopted.

In now giving you the toast of the Sudamdih Coal Company, and in wishing it every success, I have much pleasure in coupling with it the name of Mr. Sircar, who is well known to the Indian Mining world, and who I have no hesitation in saying is one of the most enterprising men in the coal trade.

GENTLEMEN,—The Sudamdih Coal Company, and Mr. Sircar.

Mr. N. C. Sircar on behalf of himself, the Company and its Directors, briefly replied thanking the President for his flattering remarks concerning the company and the enterprise it had shown in branching out into the newer form of motive power.

Mr. A. D. Wilson proposed the toast of the Mining and Geological Institute of India, to which Mr. Heslop suitably replied.

The party then proceeded at about half past two to the Government Mining Instructor's lecture room, where there was an attendance of about 70.

The President, Mr. Heslop, took the chair. After the Honorary Secretary had read the minutes of the last meeting, a vote of thanks to Mr. and Mrs. T. W. Richardson and Mr. Ashton, for their hospitality towards the Institute at an At Home given by them at No. 21, Belvedere Road, on January the 29th, at the Annual Meeting at Calcutta, was proposed by the Chairman, and seconded by Mr. T. Adamson, and carried unanimously.

Mr. H. A. Pringle's paper on "Notes on the Economics of Coal Mining in Bengal", read at the annual meeting held in Calcutta on January 28th, was down for discussion. Owing, however, to the unavoidable absence of the author the discussion on this paper was postponed to a future meeting.

The President then called upon Mr. Glen George to read his paper.

Draft Plans for a Panel System.

BY

Glen George.

(With Plates 4—8.)

In view of a strong pronouncement in a former paper read before the Institute in favour of the adoption of a panel system of working, I have thought that a discussion on such a system would be of some interest, and that the best basis for such a discussion would be an actual scheme on paper for its adoption in typical properties. I have therefore ventured to put draft plans on paper for the working of typical properties, not with the view of suggesting any arbitrary dimensions of panels and pillars, but with the idea of calling forth the views of the members of the Institute on these points and on the merits and demerits of a panel system in India.

The almost universal system at present in vogue in the average seam in India, say 16 feet seam dipping at 1 in 6, consists in working galleries 16 feet wide and leaving pillars 20 to 40 feet square. Unless dykes or faults intervene the whole of the workings are connected. By the time the boundary is reached in a fair-sized property, there is a big area under pillars. The amount of coal extracted by galleries would vary from 40 to 60 °/₀ of the whole, leaving on an average 50 °/₀ of the coal in pillars.

If circumstances are favourable, such as areas being isolated by dykes or when there is no danger of a fire by spontaneous combustion when pillar cutting, a proportion of the pillars may be taken out before the boundary is reached. But in very many instances, owing to the fact that the whole of the workings are connected by large galleries 16 feet square, the cost of isolating any area by dams is prohibitive, and the fear of a fire which would spread to the whole of the workings bars any pillar cutting. When the dip boundary is reached the pillars are taken out retreating to the rise and allowing the dip to fill with water—the safest method as regards the prevention of fire.

The great disadvantage in these cases is that you have half your coal—the half easiest and cheapest to work and most attractive to labour—locked up during the long years while your galleries are being driven to the boundary. In one instance I have in mind there are 600,000 tons of one of the best Indian seams standing in pillars, which cannot be touched for years to come. These pillars represented at recent prices an income of a lakh a year unobtainable at so favourable a juncture. Pillars are in some degree analogous to the ore reserves blocked out in a gold mine, with the great difference that those of a gold mine are always obtainable, those in an Indian coal mine not so.

The advantages in a panel system would consist in the fact that:—

(1) Definite areas would be ready for pillar cutting without danger.

(2) As pillar-cutting work is cheaper and more attractive to labour the average cost will be reduced since pillar cutting would always be going on.

(3) A reserve of working places is always at hand in case of a loss of galleries—say through influx of water.

(4) A fire breaking out from any cause can be isolated.

The apparent disadvantages are two:—

(*a*) Ventilation will be more difficult and in the case of large areas fans must be installed.

This is not a disadvantage—nothing which will tend to more efficient ventilation can be—and an essential of any panel system is the allotting of definite galleries for the air-current in place of allowing it to wander at will through the maze of galleries now open to it.

(*b*) It will lead to increased pumping.

At present when no pillar cutting is done until retreating from the dip, the water to be pumped is chiefly from the strata. Pillar cutting thick seams at moderate depths of course lead to big breaks to the surface, which in the rains allow large quantities of surface water to penetrate directly into the mine.

Whereas, in a panel system, areas are being pillar cut while work is proceeding to the dip, this would necessitate increased pumping plant.

By filling in and draining at the surface, this can be to some extent mitigated. Before giving draft plans there are certain general points for consideration :—

(*a*) Size of pillars.

As far as I have been able to judge, what would be considered reasonable in these coal fields would be as follows :—

To 100 ft. depth	..	30 ft. sq. pillars (exclusive of galleries).		
,, 100 to 300 ft. depth		40	,,	,,
,, 300 to 400 ft. depth		50	,,	,,
,, 400 and up	..	60	,,	,,

In view of the fact that the pillars would soon be cut, I would suggest increasing the size of the pillars at the lesser depths :—

To 100 feet	..	36 feet pillars.
,, 100 to 300 feet	..	50 ,,
,, 300 and up	..	60 ,,

The galleries in all cases to be 16 feet wide. Galleries at present nominally 12 feet are always 16 feet. But local conditions will always be the guide. Where the roof does not break off readily pillars would be larger.

(*b*) Size of panels.

This must vary with the local conditions and is not very material.

(*c*) Ventilation.

As the shutting off of the workings into panels will necessitate regulating the air along definite galleries, a scheme must be laid out from the commencement. This will be seen later.

(*d*) Size of pillars between panels.

This will depend first on the roof and secondly on the depth. In districts where the roof is known not to break off readily, and where a squeeze is likely to happen the barrier must be large.

In such cases a rule I would suggest would be to make the barriers ·4 of the depth (this is based on the assumption of an angle of fracture of the rocks of 70° and with a view of preventing the subsidence extending from one panel to vertically over the next).

In districts where the roof breaks off readily the barriers need only be small, say 100 feet. The coal in any such barriers would not be all lost, a certain proportion would be recovered before abandoning the mine.

Draft Plans—

In any such plans the conditions discussed must of necessity seem ideal—that the workings are beautifully regular—a regularity not attained in practice. Certainly so. But this need not prevent discussion on the principles involved.

Taking first the simple case of a property 500 to 600 bighas in area worked by two inclines, the seam being 16 feet thick dipping 1 in 10 and, in this instance, for the sake of simplicity, not cut by dykes or faults.

It is desired to lay out the workings so as to ensure constant and safe pillar cutting after the first 3 or 4 years of the colliery. The extreme width of the property is 3,000 feet, the distance from outcrop to extreme dip 2,100 feet.

In this case we may decide to arrange for two barriers on the rise and dip, which, as will be seen on the plan, means dividing the area into 9 panels.

Plate 4 shows the workings in an early stage before any panel has been formed. The size of the pillar is 38 feet. It will be noticed that on either side of the incline in each gallery a block of coal 12 feet long is left. Whenever necessary—for ventilation or haulage—these are not left solid but driven through $6' \times 6'$. In this instance every other gallery shown is driven through.

As each such opening is rendered unnecessary by one ahead being driven, it is stopped up by a pukka brick stopping. The reason for driving such openings $6' \times 6'$ in place of $16' \times 16'$ is evident: the cost of the stopping in the one case will only be $\frac{1}{7}$ of that in the other. The object of the coal blocks left and stopping is to isolate the main inclines. The middle or travelling incline is also isolated, as it has to serve as a return air-way.

As regards ventilation, in the first panels the area open will be so small as to render its consideration unnecessary.

Still the arrangements adopted in every panel is shown. Pumping is done in the travelling incline No. 3, the exhaust steam pipe making it the upcast.

Each incline is an intake. The course of the air is shown by arrows.

Plate 5 shows the working in a much later stage of development. Panels I, II, III and IV have been entirely pillar cut; V, VI, VII and VIII are being pillar cut. The last and dip panels are being developed.

A pit has been put down for pumping. The ventilation is arranged as indicated by arrows. Brattice sheets or doors send in splits to the pillar districts.

When the working face has reached the boundary the last panels are pillar cut from the dip, allowing the water to accumulate. The pillars supporting the incline are cut retreating.

As much as possible is taken out from the barrier between the two hauling inclines and from the pillars separating panels. The place where most coal will be left is in the barrier between the inclines. Even here a considerable amount can be got by carrying to the surface up the travelling incline.

I will endeavour to make a rough financial comparison between this method of working the property and the method of driving to the dip before pillar cutting.

The wastage in pillar cutting will be the same in both cases. But in the proposed method the loss in the pillars which has served as barriers will be greater.

Take it that the recovery from these pillars is $\frac{1}{2}$ as much as got from the others. Then assuming that 70 %

is the normal recovery from pillars, 35 % extra will be lost in these pillars. This in the whole area will be 90,000 tons. This represents the coal lost as a result of leaving barriers, and amounts to 3 % of the total coal in the area.

The additional pumping cost per ton owing to the increased water will be, assuming increased quantity is 30,000 gallons per hour :—

Cost of Plant: —one Lancashire Boiler, one Vertical, one 18 × 10 Duplex Pump, with erecting		Rs. 20,000
Depreciation on this, at 10 % per annum ..	Rs. 166	per month.
Wages and Stores ..	,, 80	,,
100 tons Dust, at Re. 1 per ton	,, 100	,,
	Rs. 346	

On an output of 7,000 tons per month = ·8 anna per ton, or say 1 anna per ton.

These are the increases in cost or losses. Against this the increased output due to always having pillars to cut, giving increased working room, should be 750 tons per month per incline or 1,500 tons in all. That is, in place of an output of 5,500 tons an output of 7,000 might be expected. Taking establishment and standing charges at 12 annas per ton, these should be reduced by 3 annas. So that in spite of the cost, increasing pumping, the cost per ton should be less by 2 annas per ton.

But neglecting this the increased output should at Re. 1 ton profit, mean an increased yearly profit of Rs. 18,000 always obtainable at favourable junctures. These figures involve a great assumption, that is, a sufficient labour supply. But to look at matters from the purely mining point of view this must be here assumed. Neglecting, however, these estimates which may be considered problematical and only serving to show the improbability of an increased cost, the coal lost in barriers is well repaid by the security against loss of the whole area by fire alone.

The second case I propose to consider is that of a large deep property, say 2,000 bighas, to be worked from a pair of centrally situated shafts 850 feet deep. This is the case of the immediate future in India and must lead to some alteration in the method of laying out workings. Such shafts would be fitted so as to be capable of raising 20,000 tons per month between them.

The capital expenditure in sinking and fitting up such pits would be six to eight lakhs of rupees at least. The value of the property as a going concern would be from 10 to 14 lakhs.

To lay out workings so as to incur the by no means remote possibility of losing the whole by fire is out of the question, and the present Indian method of forming a connected network of galleries must be abandoned and the workings arranged in panels.

Plate No. 6 gives a property 2,000 bighas containing say a 16 feet seam dipping 1 in 7. It may be assumed that the general strike and dip are known from borings and that no serious faults occur.

The area may be divided into panels as in plan; the fact that dykes and small faults may alter any such division subsequently is understood.

The shaft pillar shown is based on the angle of fracture (taken 70°) and the area of surface building to be supported. Galleries may be driven in the shaft pillar but no pillar cutting. The area of panels will depend upon experience, the area found convenient. In this case they are shown in isolated areas ultimately averaging 250,000 tons of coal gross; this is too large probably.

Plate 7 shows the workings of two panels. The upper panel has been developed and is being pillar cut, while the one below is being driven.

A A is the main intake and has an endless rope haulage.

B B is the main return carried over the panel haulage and intake C C by an air crossing.

D D is the panel return.

The course of the air is shown by arrows. Stoppings and doors are marked. On the right of the plan other panels in the course of formation are shown.

Plate 8 shows the property when approaching exhaustion, with panels as worked.

In these plans unnecessary details have been omitted. The shaft pillar is shown solid whereas it would be split up by galleries as long as no pillar cutting took place in it. The shafts are shown on the strike. Personally, I think the rise and dip arrangement better.

The question of the railway siding and the coal left to support it is not dealt with.

I think I can anticipate two of the directions which criticism will take.

In the first place that the pillars proposed for supporting main roads, etc., are too small. In regard to the first case considered, I can point to two actual instances where the roof is supported under similar circumstances by pillars of a similar size.

In the second place considered the depth is greater than that general at present. Personally, I think the dimensions given would be sufficient. But this question is entirely one for local experience. The dimensions suitable for one seam may be unsuitable in a lower seam at the same locality.

The other criticism I will anticipate is this:

In place of a comprehensive scheme of substantial solid barriers with advance drivages, the one put forward is a half measure one of pillars and barriers formed to some extent of brick dams. Yet I think that any alteration in the method of working in India to stand any chance of adoption must fulfil two conditions:—

(*a*) It must not be too radical an alteration.

(*b*) It must not require long advance drivages or at any time hamper output.

The point on which I trust a number of members will express their opinions is the size of pillars. I think the tendency in India in the future will be to both larger pillars and larger galleries.

The Indian miner is often abused for his output of 100 tons per year as compared with the 250 tons of the English miner. It must not be forgotten that he has to cut coal in dead ends, to cut a strip 15 feet wide with the solid on either side. An increase in the width of the galleries would help him considerably if it could be got without risk of a squeeze or excessive timber.

Provided the pillars are also increased large galleries need not mean squeeze, as the controlling factor is really the ratio of pillar to gallery.

The question of timbering is much more difficult since timber is so expensive and the miner so unskilled, and in many cases renders an increased width dangerous and out of the question.

In conclusion, I would say I have submitted this paper with considerable diffidence as it contains much that is very obvious, and I only trust it will lead to a discussion that will justify its existence.

Discussion.

Mr. C. H. McCale said:—Mr. George's paper is a very interesting and instructive one and should naturally induce many of the members to give their experience of the open work in India, and those members who have been in the country for a long period of years might be able to express their opinion as to what probable improvement would have resulted had the mines been designed on the Panel system similar to Mr. George's suggestion.

There are some seams in India which are so liable to spontaneous combustion that it would be futile as far as economy is concerned to attempt to work them on the open method. In these cases they are being wrought on the Panel system.

The Giridih and Assam coalfields are mined on this principle. The Warora coalfield also was worked in panels. Outside these there are but very few collieries designed on the Panel system in this country.

Modifying the Present System.

I concur with Mr. George in his statement that as the mines in this country get deeper something will have to be done in the way of modifying the present system of winning the coal. Indeed at the present depths accidents have occurred which in themselves have given abundance of evidence that had the mine or mines been designed on similar lines to what Mr. George has drafted, the serious damage and heavy losses resulting thereby would have been very materially mitigated, if not absolutely obviated. Therefore the advantages of such a principle of winning coal is obvious.

The only possible objection to the introduction of Panel system in an entirely new mine would appear to be initial outlay and delay of remuneration; but after all to open and win an extensive mine on the open method is what one might term 'false economy,' as the panel method of working, although it takes a little longer time to yield a return, soon pays for the extra interval of time and higher initial outlay.

Definition of Panel System.

An important point which Mr. George has omitted to mention, although it might have been understood, is that it does not matter whether the coal is wrought on the "Pillar and Stall" system or any of its modifications or on the "Longwall" method, the mine can be divided into "Panels." By "Panel" system is meant that a mine is divided into districts of definite areas flanked by barriers of solid coal.

Chief Advantages.

The chief advantages of the Panel system if introduced in Indian mines, in my opinion, would be—

1st—Fires could be dammed off in the shortest possible time with the least risk and the smallest possible area to be enclosed. There are several instances of fires which have more than proved the great disadvantage of winning coal on the present system.

2nd—Danger from "Blasts" caused by large subsidences is reduced to a minimum. We have all read or heard, if not actually experienced, the results of a blast caused by a large subsidence in an open mine.

3rd—The great waste of coal by the present system is immensely reduced.

4th—It facilitates a more regular output and of better quality. It is quite apparent that to raise large round coal will become an important factor in the future.

In addition to the foregoing advantages there are numerous others.

Disadvantages.

The only disadvantage, in my opinion, in the Panel system, as mentioned by Mr. George, is the extra water after subsidences have occurred. I have a case in mind, where, before pillars had been extracted, pumping had to be done only for about 5 to 6 hours during the day to maintain the mine dry, but after pillars had been cut and subsidences taken place a larger pumping plant had to be installed and additional boiler power was required. The pumps had to be kept working practically 18 out of the 24 hours to deal with the extra water.

Ventilation.

In the present system of working doubtless all the members, or rather those who are actually connected with the management of mines, know the difficulty that is experienced, owing to the ignorance of the labour, in maintaining the brattice sheets, etc., in proper order, and this, together with the general system of natural ventilation, renders artificial ventilation more difficult. Personally, I think, the Panel system would tend to somewhat remove this difficulty and would be a means of improving ventilation in general. But naturally this method of working would necessitate the installation of a mechanical ventilator. Each panel would have its own "split" of air, therefore air crossings or "overcasts" and regulators would have to be largely used.

Area of Panels.

The area of panels materially depends on whether the coal is or is not liable to spontaneous combustion. If it is, I would recommend, from my own experience, that the area of panel when divided into pillars should not give more than two years' working. Fires or spontaneous ignitions in such a seam of coal have been known to occur within a period of two years after pillar work had been commenced. If the coal seam is not so liable to take fire larger panels may be formed.

Thickness of Barriers.

In addition to what Mr. George mentions regarding the conditions which have to be considered in determining the thickness of barriers dividing panels, it is essential that the thickness and nature of coal seam, nature of jhill or floor and the angle of dip be considered.

It is well to note that it is generally understood that for moderate dips the angle of fracture lies practically half-way between the vertical and normal to the planes of stratification.

The strata do not break at right angles to the planes of stratification, and in order to simply protect one panel breaking over the barrier into another panel, and also to avoid any possibility of damaging objects on the surface, it is of paramount importance to know what the probable angle of fracture will be. For dips under 30 degrees the angle of fracture is said to be equal to 90 degrees minus half the dip in degrees. And for dips of 30 and above 30 degrees the following is considered a good rule[1] by which the probable angle of fracture can be more correctly calculated.

$$\frac{1+\text{Cos.}^2\, d}{\text{sin. d Cos. } d} = \text{probable angle of fracture.}$$

The following are a few results computed by this rule :—

For a dip of 30° the probable angle of fracture will be 76°-10′

Do.	50°	do.	70°-50′
Do.	60°	do.	71°-00′
Do.	80°	do.	80°-50′

The amount of subsidence after the pillars have been cut varies according to the depth of coal seam from the surface, and the thickness of coal seam, together with the nature of whole section of strata from top of coal seam to surface.

Subsidences should, to be on the lines of safety, always be expected to extend beyond the point where the coal has been actually worked out.

With ordinary strata on thin seams of coal, such as we find in the British coalfields, subsidences are said to very seldom extend beyond the point where the coal is actually worked out more than one-third the total depth the coal seam worked is from the surface; that is to say, if we have a mine 450 feet deep and a seam of coal, say, 6 feet thick, and after some considerable area of the coal has been worked out, the greatest possible "draw" or "pull" would be 150 feet over the point where the coal is worked out.

In working a seam of coal 12 feet thick at a depth of 145 feet, in an Indian mine, the "draw" or "pull"

1 Hausse's Rule.

extended fully 87 feet beyond where the coal had been practically worked out. Again in working the Dudley seam of coal which is about 30 feet thick in South Staffordshire, England, subsidences are always found far beyond the point of coal actually worked out.

Size of Pillars.

Practically the same conditions for determining the thickness of barriers will have to be considered in fixing on the size of pillars necessary to support a shaft. It must be understood that no hard and fast rule can be laid down for determining the requisite size of pillars, experience being the safest formula in solving this question.

Shaft pillars 120 feet square, *i.e.*, four of such pillars supporting one shaft, at a depth of about 350 feet, and ordinary pillars about 40 feet square with galleries 14 to 16 feet wide, coal 14 feet thick and inclining 1 in 6, have shown considerable weakness.

In my opinion, it would be safe to say that a shaft about 400 feet in depth, coal 14 feet thick, dip 1 in 6, would require 4 shaft pillars, each nothing less than 150 feet square, and the ordinary pillars 55 to 60 feet square. The width of galleries should not on any account exceed 14 feet.

A pair of shafts 450 feet deep and 450 feet apart on the strike of seam whose thickness is 12 feet and having an inclination of 1 in 5 should have supporting pillars 150 x 375 feet to the dip side and 216 × 375 feet to the rise side.

The largest pillars should always be on the rise side of shafts.

To design a mine to work a seam of coal say from 6 feet and upwards in thickness, with a view to reduce the wastage to a minimum and consistent with safety about 75 per cent. of the coal should be left solid. From this it will be easy to calculate the size of pillars required.

Mr. George is of opinion that in future the tendency will be to increase the size of pillars and widen the galleries. Of course, this is like splitting the difference between the present and the early days when the tendency would appear to be to widen galleries and leave no pillars, making quite a recreation ground. I am of opinion that when a gallery is 16 feet wide, no matter what size the pillars might be, it would not be advisable, on the side of safety, to increase on this, otherwise there would be every probability of large consumptions of timber to support the galleries.

The various beds of strata usually break by shearing. This is practically our daily experience, and the strength to resist this is dependent upon the size and distance apart of the supports. Therefore, there seems to be a limit to the width of a gallery; and even if the roof is of a very tenacious nature, I would not care to recommend the width of galleries to exceed 16 feet without using timber for their support. I fear if wider galleries were made, accidents from falls of roof and sides would considerably increase. For this reason a limited distance between props and settings is enforced in the British mines.

Indian Miner versus *British Miner.*

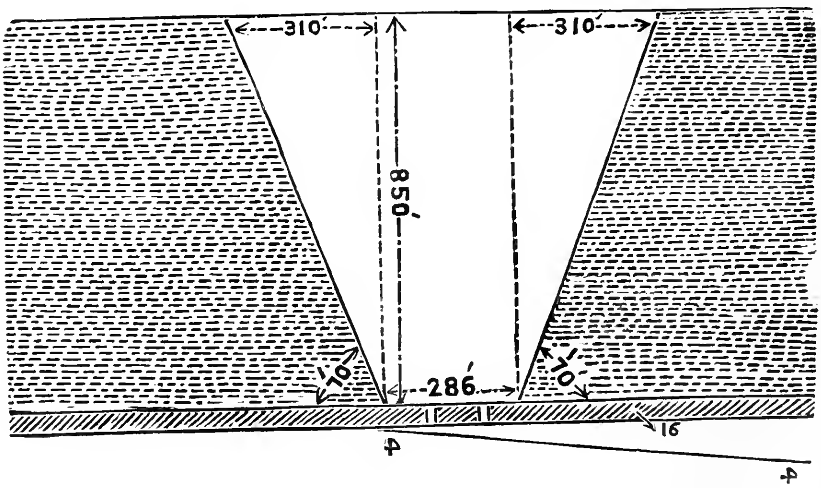
We cannot with fairness compare the annual output of an Indian miner with the output of a British miner, for we know quite well that the Indian miner does not work with so strenuous an effort as does the British miner. I have seen plenty of loose coal available in Pillar work, and because it has been the custom of one miner to only load one tub, he would not load more than one tub, and afterwards leave the mine. Many miners go down the mine at about 8 o'clock, and sometimes later in the morning, and come out again about 3 o'clock in the afternoon after loading the recognized tub of coal. There are others, of course, who go down the mine earlier and come out later, but after all, they only fill one tub of coal. They sit down chatting and smoking Hookas the greater part of the time, quite different to a British miner. Time is no object to the Indian miner, only when he wants to get near the "Grog" shop. There are exceptional cases where one miner will cut and load 2, 3 and even 4 tubs of coal, but these are very few indeed. The low rate of production is not altogether due to "Fast" ends.

Mr. W. T. GRIFFITHS said:—I do not propose dealing with many of the questions raised in this paper, but one or two points appear to be not quite in order. Dealing with Plate No. 5 generally it will at once be evident that the system illustrated consists in dividing the property off by stoppings into a number of areas, the whole being cut up by galleries into pillars with one medial barrier. It is utterly wrong and misleading to describe this as a panel system. In such a system each area should be surrounded by solid barriers of coal of such dimensions that any thrust or creep occurring within its boundaries due to any cause whatsoever would be prevented from extending to any workings external to it, and the number of openings into a panel should be the irreducible minimum. It is readily conceivable that an explosion of fire-damp or a powerful air-blast would easily blow to pieces the ordinary Indian kutcha brick stoppings, although only $6' \times 6'$ in area, and thus spread its effects over the mine. In plan

No. II there are in reality only two panels one on each side of the medial barrier.

Another point which is of importance is that for the same output a panel system is more expensive than the ordinary method of working, and the output of any particular shaft would have to be considerably increased in order to maintain an equivalent cost. At present a large proportion of the coal worked in Bengal is mined directly to the dip, and the inter-connected galleries render both ventilation and supervision easy. The question of dealing with water is simple, for pipes can be laid in any direction and, if necessary, as in the case of dealing with large quantities of water, a proper drainage system can be established without difficulty. The amount of timbering performed is infinitesimal. Now in the panel system the supervision must be considerably improved. Splits of air have to be arranged for the panels. Doors, air-bridges and ventilating appliances will be increased in number, and there will be many more rise galleries to be ventilated. Owing to pillar cutting proceeding concurrently with gallery working, close attention must be paid to timbering, roof falls, and blasting. Such supervision owing to the ignorance of the miner must be by trained Europeans. We have also the fact that in the dip panels water will have to be drained from each separately, in most cases by pumping. Finally there will be more footage paid for the driving of main galleries in order to open out the panels. In order to meet the extra cost of supervision, timber, pumping, etc., the saving effected is that due to the difference in price paid the miner for a tub of coal in gallery and pillar working, which sum is, in nearly all cases, less than $1\frac{1}{2}$ annas per ton and is insufficient to meet the additional expenditure unless the output is increased.

I next wish to deal with the question of subsidence. This is a very important subject and Mr. McCale has given us many particulars and formulæ with reference to results obtained in Europe. In India, however, there appear to be no records available, and the conditions are so entirely different that accurate observations should be made in order to arrive at some rule or definite conclusion. It is well known that large areas of coal are left to support various surface works in the colliery districts, and



it is possible that owing to dearth of information the margin of safety demanded is excessive. Considering Plate No. 8, I wish to discuss the effect of subsidence on the barriers, taking the angle of fracture assumed by Mr. George, *viz.*, 70°, and the width of the galleries in the barriers to be 15 feet. The total effective width of coal to the rise and dip of the main levels is 256 feet, and we may neglect the effect of the dip which at 1 in 10 is small. Taking a cross section through the seam to the surface the position would be as shown in the sketch. Supposing the superincumbent strata were resting freely on the barrier, and assuming the weight to be 1 lb. per square inch for each foot in depth, then the pressure on the coal would be nearly 2,000 lbs. per square inch. The crushing strength of coal is from 2,000 to 4,000 lbs. per square inch. Hence if we take the weakening due to cleavage and faults into consideration it is evident that the size of this barrier is very near the limit. Of course it is impossible to gauge what supporting effect the subsided areas on each side of the barrier may have, but the protection of the long levels connecting the workings at extremities of the property with the shafts appears to me to be insufficient. If the barrier was increased in width, in addition to its acting as a stronger support until the workings had reached the boundary, it could afterwards be extracted with greater safety. In Plate No. 6 the shaft pillar is shewn to measure 450 feet from the shafts to the rise and 650 feet to the dip. This is an error, and the plan should be altered so as to reverse these dimensions.

Mr. Thos. Adamson, Jherria, said:—The advantages of the Panel system of working coal over that of cutting up the whole of a mine into pillars, none of them would dispute, and they were all indebted to Mr. Glen George for bringing this subject before them in his most interesting paper.

To his mind it was more of a Bord and Pillar system than that of a Panel system, shown in Mr. George's Plate No. 5.

In a Panel system the main roads are driven in such a way that they are supported by barriers, and not by pillars as shown on the plan. Then, in case of fire, or an influx of water, two openings only would have to be built up, instead of the many openings between the pillars as shown by Mr. George.

He did not approve of Mr. George's proposal to take out pillars in a seam 16 feet in thickness, so near the surface, in a practically new mine.

The surface subsides where the pillars are taken out, and in the rainy season lets into the mine large feeders of water.

When barriers are formed, however, some of this water can be dealt with at a comparatively shallow depth: taking Panels 1 and 2 on Plan II, the depth would not be more than 100 feet. Without barriers the feeders of water would run into the deep workings, and would have to be dealt with there, and pumped a vertical height of 300 feet.

Mr. George assumes the extra feeders to be 30,000 gallons per hour, and estimates the cost of pumping this to be one anna per ton on 7,000 tons raisings per month. Mr. George states that a Duplex pump 18″ × 10″, and one Lancashire boiler, and a vertical boiler, would do this work. In practice they found it would take a pump 24″ × 10″ and at least two Lancashire boilers to do the work. It would be necessary to duplicate the pump, so that in case of a breakdown of one pump, there would be another to fall back on, and thus save the mine from being drowned.

The plant to do this would not cost less than Rs. 60,000, which, with an output of 7,000 tons per month, would increase the cost per ton by three annas.

Pillars of course must be taken out, but the time of doing this should not be hastened.

Take a Colliery with a life of say 20 years. If pillars be taken out during the first 5 years, and surface dropped, the water which finds its way into the mine from this broken surface has to be dealt with (pumped) until the mine is worked out.

Again, leaving two rows of pillars 36′ × 36′ only on each side of the haulage roads, surrounded by galleries 16 feet in width and 16 feet in height, is likely to give serious trouble. If, after the pillars have been taken out as shown in Panels Nos. 1 and 2, all the roof does not break down, then the remaining pillars, those left to support the haulage roads, have not only to support the strata directly over them, but also the overhanging roof in the adjoining goaves. This, with a roof like what he (Mr. Adamson) has had considerable experience with, might be anything up to 200 feet in width, which would crush out these pillars and ruin the mine.

In reply to Mr. Adams, Inspector of Mines, Mr. Adamson said that his experience is that pillar work is popular with the coal cutters, and that when he started pillar cutting in Jherria he reduced his cutting rate from -/5/- to -/3/6 per tub of 12 cwts., and that the coal-cutters' earnings were higher when cutting pillars, than when driving galleries.

Against this of course is extra cost in supervision, timber, and in some cases water pumping.

Mr. G. F. Adams stated that in Jherria galleries were not driven as a rule as wide as 16 feet. In some cases where they had been driven as wide, the management had had cause for regret. Not that he thought that the width was excessive if pillars were made correspondingly larger than was usual in the coal field, but experience had proved that it was excessive with the size of pillar generally adopted.

Closely allied with the question of panels was that of pillar getting. He thought that if those members who had had practical experience of pillar getting would furnish information as to the relative cost of coal got from pillars and coal got from gallery driving, such information would be valuable.

He thought the discussion should be adjourned, and resumed at a meeting in the monsoon, so that Mr. George could finally reply to the discussion on his return to India in the cold weather. He did not think 9 months at all too long for the consideration of all the points brought up by Mr. George's valuable paper.

Mr. W. J. Greener said:—From his own experience he could not agree with what Mr. Adams had said, as he had found the cost of working "brokens" to be at least two annas a ton cheaper than working in the solid; these figures were taken from actual work where pillar drawing and cutting out was going on simultaneously. In making these remarks he was referring to seams of 8 ′0″ and under.

Mr. N. C. Sircar said:—Although I am not a member of the Institute I may be allowed the liberty to speak from personal experience. I have seen that pillar cutting is a bit more expensive than getting coal in the ordinary gallery driving. It may be an inducement to the miners, but they do not accept a lower rate for pillar cutting and, taking the cost of timber and extra supervision into consideration, it costs -/2/- to -/3/- more than gallery coal.

There may be a bigger output whilst they are drawing pillars, but whenever there is a fall of roof, the mine is stopped for 2 to 3 days, which counterbalances the extra coal got by pillar cutting.

Mr. J. R. R. Wilson:—This paper has certainly achieved what I imagine the writer desired, that is, promoted a most interesting discussion, and I hope the discussion will be continued. It has moreover been the means of obtaining for us information which I have been seeking for years. Mr. McCale has presented us with a code of rules with regard to subsidence which apparently fits every occasion. I confess that I am much behind the times. I have followed with interest what has been written upon the subject by German, French and English mining engineers, particularly the work of Monsieur Fayol and Mr. Galloway, and nowhere have I been able to glean anything so precise as that presented to us to-day. The subject bristles with difficulties, and I am afraid that we shall still have to carefully examine every individual case and take into consideration the depth, inclination and nature of the strata and then be guided by all the circumstances surrounding it. I hope however that Mr. McCale will give us his authorities for the rules he has quoted, and perhaps the writer of the paper will do the same.

Mr. George:—I speak only from experience.

Mr. Wilson:—Well, it is very essential that we should lose no opportunity of informing ourselves upon this point: it is of great importance to Indian mining. If we can only persuade members to carefully observe all fractures that take place at their own mines, and record the nature of the strata and the angle of the break, we shall doubtless obtain some good guide for future working.

As to shaft pillars, opinions vary very much as to the size they should be. Belgian mining engineers would probably tell us that 50 metres was wide enough for any depth. In Westphalia one finds pillars equal to a quarter of the depth of the shaft. In England many authorities say, make the size of the pillar equal to the depth of the shaft. Perhaps one is not always clear about the reason for big shaft pillars. Mr. McCale seems convinced it is connected with the "draw." I think that in England the large size can often be attributed to the trouble arising from creep, and the necessity for maintaining a proper road to the shaft.

With regard to ventilation, I quite agree that any system of ventilation would be more expensive than that obtaining at many mines. It is distinctly new to hear that brattice cannot be used because the Indian miner would steal it--presumably to make his clothes with it. I must confess that I have visited many mines where there was not sufficient brattice to make a suit of clothes.

The discussion so far seems to have revolved more or less around the question of support rather than upon the exact subject of the paper. I should have thought that we were all agreed upon the necessity for the adoption of panel working in India, and that the only question was one of ways and means. I am not certain that I agree with the plans suggested by the author of the paper, and rather think that they leave much to be desired. I have already written some notes on this subject which will reach most of the members through the medium of the Annual Report of the Chief Inspector of Mines, and the reason stated there for the adoption of the panel system are shortly, that the risk in case of fire or sudden inrushes of water is reduced to a minimum; better and cheaper coal is produced from pillars systematically extracted; and there is a quicker return upon the capital expended than would be the case if all the pillars were left until the boundary were reached.

The President said: GENTLEMEN,—We have had a very interesting discussion on Mr. George's excellent paper.

One of the several points raised is the question as to the success or otherwise of pillar working. Opinions are divided on this point, but personally, I have no doubt, and from my own experience, that more coal is obtained in pillar working by the Indian miner, and with a resulting cheaper cost. The Indian miner has no prejudice against pillar working, such as he has, against what he regards as new innovations like that of coal-cutting machinery, but on the contrary I have found him distinctly partial to it; and in fact he is rather given to doing a little pillar robbing, if he can get a chance to do so.

In the past the working by panels or districts has doubtless been greatly neglected, and in consequence of which large areas of coal have been lost, which if they had been worked on the panel system would have been avoided. For very shallow depths and small areas its necessity perhaps may not have been so greatly felt, but for the present deeper mining and the still greater depths of the future, involving the outlay of many lakhs of rupees, the loss of so valuable a property cannot be risked, and against which, the only safe principle to adopt would be to lay out for systematic panelling, and facility for isolation. Mr. George has doubtless made good his points and given convincing reasons on the advantages of the system, while it is very difficult to find any real disadvantages—for though there is the increased expenditure on pumping plant and cost of working on the extra water that may be expected, this would be quite discounted by the large profit that would result from the increased output. I quite agree with Mr. George that the apparent disadvantage in increased expenditure on account of ventilation, would really be no disadvantage at all, but on the contrary any improvement in ventilation would be a step in the right direction, and would be a distinct gain in the working conditions of the mine.

Further discussion of the paper will now be adjourned till a future meeting, and in the meantime I have very much pleasure in proposing a hearty vote of thanks to Mr. George for his very valuable paper.

The discussion on this paper was resumed at the Asansol meeting held on the 29th August, 1910, and is as follows:—

MR. STUART MCMURTRIE considers the paper a valuable one because it magnifies the importance of pillar cutting. Hitherto in Indian mining the chief source of coal has been the "whole" workings, and if it is so to continue then we must aim at making the pillars as small as may be compatible with freedom from heavy crush and make the galleries as wide as possible; but, he conceives that the "whole" workings should no longer be the chief source of supply but should be regarded merely as a means to an end, and he looks forward to a not very distant future when coal shall be produced in much larger quantities and at a reduced cost from the "broken" by a class of skilled overmen with a fair amount of safety, particularly because in India we have such great advantages as good roofs, good floors, hard coal, freedom to a large extent from gas and spontaneous combustion. We owe very much to the scarcely retired generation of mining engineers who have to a large extent both commanded success and deserved it by bringing labour from long distances to the mines and overcoming native prejudices, but to convert aboriginals into skilled miners *ek dam* were an impossibility, and we must make still further progress from the point to which it has been brought. There is much scope for this in the matter of which Mr. Glen George has written.

The author of the paper invites expression of opinion on the matter of pillars, size and width of galleries. As regards the former he thinks that Mr. Glen George's greater dimensions may serve for 16 feet seams, but there is much coal in Bengal over 16 feet thick, and rules for respective thicknesses might be suggested; nevertheless, these should be regarded merely as a minimum and the sizes actually determined by economical conditions, remembering that the larger the pillars the larger the percentage of steam coal and the smaller the proportion of slack. Accordingly pillars of 90 or 100 feet square might be found suitable if the chances of driving out the roads quickly and other circumstances were favourable. For galleries, 16 feet seems too wide. It is fortunate that the roof in this country is so good because it can, in thick seams, be examined and timbered only with the greatest difficulty; we are specially fortunate in this, but we are not more than ordinarily fortunate in the matter of the sides which are nearly as difficult to examine and quite as difficult to timber. Should these become loose a stretcher would be applied; now if the road be 10 feet wide it is no easy matter putting up this at a height of perhaps 17 feet, but if the road be 16 feet wide, owing to the much greater weight of the required roller, the task becomes so very much more difficult as to deter from and militate against sufficient support and safety. There is more to be feared from falls of side than from falls of roof under the conditions being discussed. A very strong and obvious reason for narrower roads is the greater progress they obtain. The conclusion is that if, as suggested, the "broken" is to be the chief source of output and the "whole" the means to that end, the circumstances of larger pillars and narrower roads combine to attain it.

As regards ventilation Mr. Glen George states that with the panel system it will be more difficult and, in the case of large areas, fans must be installed, and that this is not a disadvantage. Now while ventilation is a recognised necessity and in mines worked by shafts, often also in outcrop workings, it must be attained by a fan or shaft furnace with a system of coursing round the faces, yet in the thick seams of Bengal large areas on the outcrop where neither inflammable gas nor carbon dioxide are met with may be quite efficiently ventilated by nature, the peculiar circumstances of good air but not much necessary cooling or high velocity favouring the coal-owner. Without losing sight of the fact that mining engineers must sooner or later, and whether they like it or not, adopt artificial ventilation and course the air with stoppings, doors, etc., yet it seems not a necessary part of Mr. Glen George's scheme. It involves expenditure on Fan, Engine, Boilers, closed up-cast, doors, stoppings, brattice, etc., together with a little inconvenience from carriers taking their baskets through the above-mentioned doors, etc. This panel system might easily be adopted to many partly worked collieries if the mine-owners were not deterred by the idea that extra expense would be incurred by ventilation. Whether coursed ventilation must be applied or not depends chiefly on the size of roads, presence or not of gas, and above all on the number of entrances from the surface of which often enough there are plenty.

As for safety in case of fire or partial advantage of this sort, the panels would have to be far more isolated and the openings fewer than shown in the plans of the writer of the paper; if a fire were to break out foul air would be freely given off at nine-tenths of the brick stoppings there shown. It is marvellous how a fire will find its own oxygen and burn through the cleat past a stopping. If fires were of rare occurrence one would not look to a panel system for help, and if of frequent occurrence "square" work would be the only effective remedy, in which workings of limited area are entirely separated from one another by coal ribs save for the two air-ways. A wide distinction must be drawn between panels, adopted in all methods of working coal, and "squares" which are quite peculiar to Staffordshire and Indian thick coal workings.

As regards pumping much might be done with surface drainage to prevent influx, but if the quantity were increased by 30,000 gallons per hour probably the increased cost of raising water would be more than Mr. Glen George states. One cannot reckon on pumps working twenty-four hours daily.

The principles of this paper seem excellent: it is only in a few of the details that he differs.

Mr. C. H. McCale subsequently wrote, in reply to Mr. Wilson,—Subsidences around pillars and barriers left for support have proved most irregular in their action, and it must therefore be admitted that no theoretical formulæ could be enunciated to apply to all cases, and therefore it is quite apparent that all rules for that object are more or less of an empirical character, and subject to modification by local considerations. But in the absence of sufficient data obtained in the mines of this country we should be failing if we did not apply some considered safe rule which has been based on the experience of other countries to assure an ample pillar or barrier being left to secure practically immunity. This is why I mentioned a rule, and I myself feel sure that it would be a safe guide, if applied, until further data is obtained from which a sound and safe rule applicable to this country could be deduced.

With regard to the actual figures given, these, I had already stated, were obtained in an Indian mine after a subsidence. This subsidence occurred in the year 1901, and if I remember rightly a sketch giving plan and section of same was submitted to the "Department of Mines" some time in the year 1902. I regret the inability to produce a copy of the sketch, but for the information of members I give below an excerpt from an article[1] by the writer, from which they will glean full particulars of the subsidence in question:—

"Some few years ago the writer experienced a similar "subsidence in a colliery which was then under his charge, "and in the Deshergarh district, lying to the north of De-"shergarh colliery. The subsidence extended over an "area of about 35,000 square yards, but this particular "colliery had a thinner and slightly different cover, and "only reaching a matter of 145 feet thick, consisting "mainly of sandstone beds, as will be observed from the "section of strata."

"The very largest of the pillars left to support the "roof in the area subsided was about 15 to 20 feet square, "and the greater number of them did not measure more "than 10 to 15 feet by 4 to 5 feet, and some not even "this. This area had been worked some five to six years "prior to the subsidence, and the reason of it taking "place so long after the actual working may be attributed "to the very thick and strong band of 'Jhama' or "burnt coal, in many parts reaching 5 to 6 feet thick,

1 "On Indian Coalfields." Can be obtained from Science and Art of Mining, Wigan, England.

"next to the roof, practically all over the area subsided. "The seam of coal is 12 feet thick, and 5 to 6 feet being

— SECTION —

Total Depth Ft	In	Strata	Thickness of each Stratum Ft	In	Description of strata
17			17		Alluvium
33	5		16	5	Black shale (soft)
43	6		10	1	Light grey sand stone (hard
55	7		12	1	Black shale
66	1		10	6	Light grey sand stone
68	1		2		Dark grey sand stone
124	4½		56	3½	Light grey sand stone (hard)
126	10		2	5½	Black shale
138	10		12	.	Coal (Sanctoria)
143	10		5	.	Fireclay

"burnt next to the roof, only 6 to 7 feet of the lower "section was actually worked out; after the subsidence "the break or fall on the surface was measured to be "about 5 feet at the deepest point, or an average of about "3 feet. The 'Draw' or 'Pull' of the subsidence was "fully 87 feet beyond where the coal had been divided "into extremely small pillars."

Mr. Wilson queries as to whether I calculate the size of ordinary pillars from the "Draw" or "Pull." I believe that I have already mentioned the conditions on which the size of ordinary pillars, shaft pillars and barriers respectively really depend. The "Draw" or "Pull" need not be taken into consideration when determining the size of ordinary pillars.

Members who are anxious to follow up this subject are referred to an invaluable paper,[1] *viz.*, "On subsidence caused by colliery workings." By Joseph Dickinson, F.G.S., and also the discussion on same.

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[1] Trans., Manch. Geol. Soc., 1898.

Extraordinary General Meeting, Asansol.

Monday, 29th August, 1910.

An extraordinary general meeting of the Institute, convened in accordance with Rule 49 of the Articles of Association, and duly notified in accordance with Rule 50, was held at the Chota Nagpur Mounted Rifles Club, Asansol, at 12-30 P.M., on Monday, the 29th August, 1910. There were about 50 members present. Among them were the following :—

Messrs. T. H. D. LaTouche, Vice-President (in the chair), Thos. Adamson, R. J. Browne, L. M. Chaudhuri Thos. Emmerson, H. H. Hayden, Major F. C. Hughes Messrs. R. Heron, Chas. Lea, Geo. Miller, C. H. McCale, S. McMurtrie, J. J. Marshall, H. A. Pringle, G. N. A. Pitt, T. C. Piggford, A. Russell, A. T. Rose, R. R. Simpson, A. S. Thomson, G. H. Tipper, J. Thomas, C. L. Watson, and J. R. R. Wilson.

The business before the meeting was the amendation of Articles 8 and 9 of the Articles of Association regarding the rules for election of members.

It was proposed that the Articles 8 and 9 of the Articles of Association should respectively read as follows:—

8. A candidate for election for membership (whether as an Ordinary Member, Associate Member, Associate or Subscriber) shall make an application to be sent in to the Secretary in the relative forms A and B hereto respectively annexed, and in the case of Form A (applicable for Ordinary Membership as well as Associate Membership); the application shall be countersigned by three Ordinary Members recommending the candidate. The Secretary shall thereupon in cases of application under

Form A, refer same as soon as conveniently may be to the Council, who shall decide by a majority of its members present whether the candidate shall be admitted as an Ordinary or an Associate Member; and if it be decided that the candidate shall be admitted as an Associate Member, the fact shall be communicated to him by the Secretary, unless he has previously intimated that he wishes to join as an Ordinary Member: it shall be optional to the candidate to withdraw his application within one week after receiving intimation from the Secretary that he has been admitted as an Associate Member. The Secretary shall send a written announcement of his election to each candidate duly elected, and shall therewith send a copy of the Rules of the Institute for the time being in force.

9. The names of those proposed for election as Honorary Members shall be balloted for by the Council. An Honorary Member shall not be considered to be duly elected unless the majority of votes are in favour of his election.

The foregoing resolutions were passed without dissent on the part of members present, and with only one dissentient on the part of members not present.

Meeting at Asansol.

Monday, the 29th August, 1910.

An ordinary General Meeting of the Institute was held at the Chota Nagpur Mounted Rifles Club at Asansol on Monday, the 29th August, 1910, at 1 P.M., Mr. T. H. D. LaTouche, Vice-President, being in the chair.

The minutes of the last meeting held at Jherria on the 7th March, 1910, were read and confirmed.

The Chairman then called upon Major Hughes to read his paper.

Proximate Analyses and Calorific Values of Bengal Coals.

BY

F. Cunynghame Hughes, F.C.S., A.I.M.M.

The commercial value of a chemical analysis of coal or any other material depends entirely on the information which it gives to the user. For this reason proximate analyses and calorific tests are of more practical value to the coal consumer than ultimate analyses.

The author has made a number of analyses and calorific tests of Indian and other coals, particularly with the object of showing how the calorific power of a coal may be deduced from its proximate analysis, and how far such deductions may be relied on for Indian coals.

His attention was lately drawn to a paper entitled "Calorific value of coals as deduced from their proximate analyses," which appeared in the *Philippine Journal of Science* by Alvin J. Cox.[1]

The object of this paper is to show how the formula he uses may be applied to Indian coals and how far it can be relied upon.

Before proceeding to an explanation of the above-mentioned formula it may not be considered superfluous to give a brief outline of the methods employed in making these analyses in our laboratory, and of the calorimeters employed in making the calorific tests.

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[1] Philippine Journal of Sci., Vol. IV., May, 1909.

The methods are essentially those described in the *Journal* of the American Chemical Society[1] and in the latest edition of Blair's "Iron and Steel Analysis."

METHOD OF MAKING A PROXIMATE ANALYSIS OF COAL.

1. *Sampling.*—Parcels of coal analysed by the author consisted as a rule of a few lumps only, the weight varying from 4 or 5 lbs. up to about 50 lbs.

In all cases the method employed of obtaining a small finely crushed sample which would fill a glass stoppered bottle of about 8 oz. capacity was practically the same. The larger the sample the more often did it require to be quartered down.

Where the original parcel consisted of about 20 lbs. of coal in largish lumps, the whole lot was broken up to the size of small rubble with no pieces larger than 1 inch cube. This was thoroughly mixed on a clean floor divided into four parts by the usual method of quartering, as described in a previous paper by the author.[2]

Two opposite quarters were again crushed so that the whole would pass through a screen $\frac{1}{8}$ in. mesh thoroughly mixed and quartered down till about 2 lbs. of the coarse sample remained.

This was crushed to pass through an 80 mesh screen thoroughly mixed on glazed paper and quartered down till enough remained to fill the bottle or about 8 or 12 oz. coal, roughly 250 to 350 grammes.

The finely powdered sample was at once transferred to a bottle, corked up and labelled.

2. *Moisture.*—About 1·5 to 2 grammes of the coal

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1 Am. Chem. Socy. Journal. Dec., 1899.

2 Sampling of ores and bullion, Hughes. Trans. Min. and Geol. Inst., India, July 1907.

is weighed on to a counterpoised watch glass and heated for one hour in a hot-air drying oven at 105° to 110°C., a second watch glass being placed over it as a cover to prevent loss in transferring from balance to drying oven and to keep out dust.

After cooling in a dessicator the weight is again taken

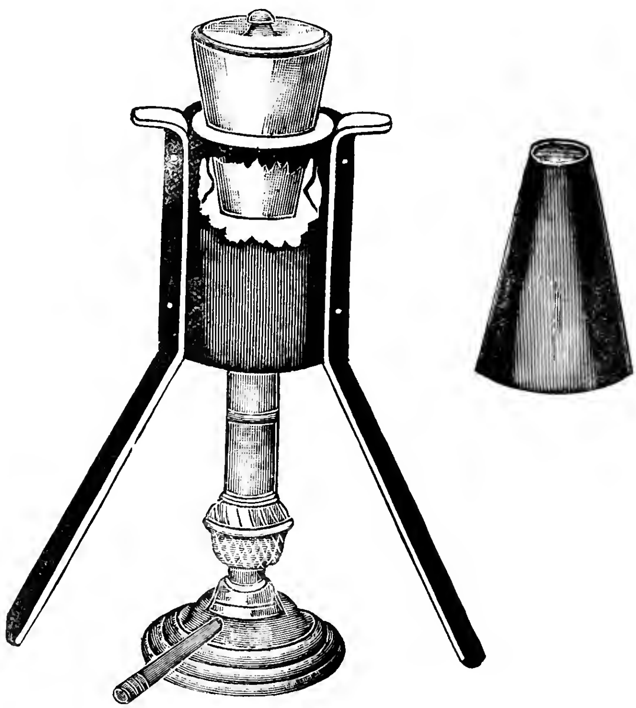

Fig. 1.—Davies' Furnace and Fletcher Burner.

and the loss calculated as moisture. It is found that the whole of the combined water is driven off in this time, and longer heating may cause oxidation to begin.

3. *Volatile combustible matter and coke.*—The author uses a platinum crucible about 2 inches high and $1\frac{1}{2}$ inches wide for this estimation. The crucible has a tight-fitting

porcelain lid. Crucible with lid is first weighed. About 1·5 grammes of coal is transferred to it direct from the bottle with a spatula and it is again weighed. Difference gives weight of coal taken. A Fletcher gas burner [1] is placed under a special type of crucible furnace called Davies' combined crucible furnace and tripod stand (*vide* Fig. 1). This excellent little apparatus is made of iron lined with fireclay (*vide* illustration), and will support with the aid of projections any ordinary sized platinum or porcelain crucible. The heat of the flame is concentrated in the furnace and there is little loss by radiation. The covered crucible is placed in the furnace, the flame being low. It is heated first $3\frac{1}{2}$ minutes with a low flame, then $3\frac{1}{2}$ minutes with the greatest heat obtainable from the burner. This differs slightly from the practice as laid down in the American Official report [2]; Cox, however, points out that with bituminous coals high in volatile matter it is better to modify this by heating the crucible first very slowly for 4 or 5 minutes till the volatiles are removed, which is known by the cessation of smoke arising from the crucible. He calls this the "smoking off" method, and has applied it to his analyses of Philippine coals. He of course finishes off at a high temperature as in the official method. With Indian coals I have generally found the above method satisfactory, but the heat should be gradually raised to its full power after the expiry of the first 3 minutes' heating

1 Modification of Bunsen Burner furnished with wire gauze over the air inlet and on top. It gives a large powerful flame and never lights back. The flame is capable of easy adjustment.

2 The method laid down in the American official report, p. 1122, is slightly different. Seven minutes over full flame of Bunsen Burner is laid down, the crucible being supported by a platinum triangle, with the bottom 6 to 8 c.m. above the top of the burner. The author prefers his modification of this determination, especially in an Indian laboratory where it is difficult to avoid draughts.

at a lower temperature. Three and a half minutes with the full flame of the burner is quite sufficient to drive off all the volatile matter in the small quantity of coal used in this determination, the coke only remaining in the crucible.

When cool, crucible with lid containing the coke is again weighed, the loss of weight is reckoned as total volatile matter and the weight of coke is found by deducting the weight of crucible plus lid from the total weight found after heating, *i.e.*, crucible plus lid plus coke.

Volatile combustible matter is estimated by deducting the moisture from total volatiles. This is of course principally carbonaceous but will also include the sulphur in the coal which is partly driven off and partly retained in the coke.

4. *Ash.*—A flat-bottomed platinum dish was found most convenient for this determination.

It is first weighed empty, about 1·5 to 2 grammes coal transferred to it and weighed again. Difference gives weight of coal.

The dish is placed on a fire clay triangle over the Davies' furnace and first gently heated and stirred with a piece of platinum wire to prevent coking. When the volatiles are expelled the heat is increased and the carbon all burnt off with the aid of occasional stirring. This is usually accomplished in about three-quarters of an hour. After cooling, the dish and ash is weighed, weight of dish subtracted and ash calculated therefrom.

Fixed carbon is estimated by deducting ash from coke.

The only other important constituent is sulphur. This has not been determined for all the coals but only in a few special cases. In Bengal coal it is almost always less than 1 per cent. and can be neglected as far as calorific power is concerned.

Determinations of sulphur were made in our laboratory by Eschkes' method [1] as modified by Arnold and Ibbetson.

This consists of fusion with calcined magnesia and soda carbonate, extraction with water and precipitation of sulphuric acid with Barium chloride.

I will now proceed to a description of the methods employed in finding the calorific value of the fuels.

There are two different units in which the calorific power of a fuel may be expressed, *viz.*, calories, or British thermal units, shortly written B.Th.U. The calorie is the amount of heat required to raise the temperature of 1 gramme of water, 1 degree cent., and the B.Th.U. is the heat necessary to raise the temperature of 1 lb. of water 1° Fahr. As the heating value of a coal is expressed by the number of centigrade degrees of temperature which 1 gramme of coal will raise 1 gramme of water, *i.e.*, calories, or the number of Fahr. degrees 1 lb. of coal will raise 1 lb. of water, *i.e.*, B.Th.U., it follows that the two figures will vary in the ratio which a Fahr. degree bears to a Centigrade degree. Therefore 1 Cal. is equal to 9/5 B.Th.U., or to find number of B.Th.U. corresponding to a given number of calories, the latter are multiplied by 1·8.

The calorific tests made in our laboratory were carried out with Fischer's and Thompson's calorimeters. Fischer's apparatus and the tests made with it will be dealt with later on. Theoretically it should give accurate results, and there are no empirical corrections such as are required with Thompson's. Practically the author often found

[1] Steel Works Analysis by Arnold and Ibbetson, p. 389.

some difficulty in securing complete combustion of carbonaceous matter.[1] Thompson's apparatus leaves much to be desired, and only approximately accurate results can be expected with it. When carefully worked concordant results can be obtained, but the fact that results are concordant does not always prove them correct, and with some coals the errors may run to over 10 per cent. when compared with results obtained with a bomb calorimeter.

By modifying the treatment from that laid down by the inventor in a manner which will be described later on, results were obtained more in accordance with theory, and with those obtained with a calorimeter on which complete reliance for scientific accuracy can be placed. For this reason the author thought it advisable to make some check determinations with the Mahler Bomb Calorimeter and has to thank Mr. W. Tate of the Sibpore Engineering College for kindly placing the apparatus at his disposal.

Mahler Bomb.—With this calorimeter the fuel is burnt in a steel bomb in oxygen at a pressure of 20 atmospheres. One disadvantage of this instrument is the necessity for the use of oxygen cylinders. These are both expensive and difficult to obtain in India. At Sibpore they use a pressure pump drawing the gas from a holder which does away with the oxygen cylinders. Where a number of determinations is required this would be found inconvenient and laborious. The apparatus is expensive and requires considerable skill to manipulate properly. All these reasons debar it from general use out here; and recourse is usually had to some simple apparatus like Thompson's.

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[1] The difficulty has now been overcome by the use of electric ignition: *vide* note on p. 119.

Though unsuitable for the ordinary worker who has not the appliances of a modern laboratory at his disposal, it is by far the most accurate and reliable form of Calorimeter in general use, as perfect combustion is assured, the whole of the heat is retained in the combustion chamber

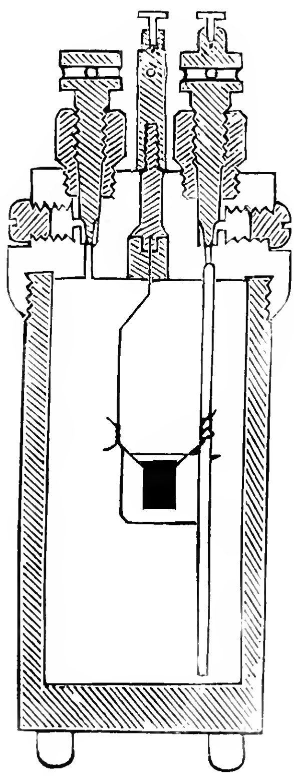

FIG. 2.—Mahler's Calorimeter (Section of bomb.)

or bomb and given up to the calorimetric bath, the products of combustion not passing away as is the case with other types of calorimeter.

The coal is first compressed in a special screw press into a pellet about ·8 gramme in weight. It is accurately weighed together with a piece of fine iron wire about 7 cms. in length which is also weighed. The wire can be conveniently attached to the coal pellet by placing it in the mould together with the coal, the ends being left outside. Fig. 2 gives a sketch of the apparatus in section. The steel bomb is lined with acid-resisting enamel. The cover which carries the valves for the introduction of the oxygen, is provided with an insulated firing plug and platinum supports for the crucible and ignition wire. This cover can be securely screwed to the body of the bomb after the coal pellet has been placed in the platinum crucible and the ends of the wire attached to the platinum rods to secure contact for the electrical firing.

After fixing the pellet of coal in its place, the cover is screwed on firmly with a special spanner provided for the purpose, which renders the bomb gas-tight. It is then connected to the cylinder of oxygen or pump, whichever is being used, by means of a copper tube provided with a cone and nut. The inlet valve in the cover is slightly opened and the gas admitted till the pressure gauge shows a pressure of 20 atmospheres. The valve is then securely closed, and the bomb disconnected.

The metal calorimetric bath, which in the Sibpore apparatus is removable from its wooden holder, is counterpoised on a balance, and about 2000 grammes of water at about room temperature transferred to it. I found it more convenient to use a constant weight of water for all experiments by pouring in approximately the correct amount and adjusting it finely to the weight required with a pipette, than to measure out a certain volume of water and then take its weight.[1] 2000 grammes

[1] This also simplifies calculation; and the author's experience has shown him, that it is advisable to have as many constant factors as possible in any

was found sufficient to cover the bomb completely and was used in all my determinations.

The bomb is placed in the calorimeter, the stirrer and thermometer fixed. The stirrer is worked by a small motor. The electrical connections are then made, and, after one or two readings of the thermometer have been taken at regular intervals of one minute, the current is switched on which ignites the wire, combustion of the coal being almost instantaneous. Regular readings of the thermometer are taken at intervals of one minute till the maximum is reached, and afterwards readings are continued to make allowance for heat lost during the experiment. This correction is made sufficiently accurately by estimating the fall in temperature over a definite time, and adding a proportionate amount to the net rise of the thermometer. Thus if the temperature falls ·04 degrees in 4 minutes and the thermometer took 10 minutes to rise to its maximum after firing, then $\frac{\cdot 04 \times 10}{4}$ equal to ·10 degree is the correction to be made. Another way of making this correction, which is still more exact, is by plotting a curve of the temperature as Ordinates and the time as Abscissae extrapolating to determine the actual temperature which would have been attained had no subsequent cooling occurred. When the precaution is taken of starting with water at or very near room temperature the first method is quite accurate enough for practical purposes.

The water value, that is the quantity of water which must be allowed for in excess of that actually used owing to the absorption of heat by the calorimeter, bomb, stirrer, etc., is calculated once for all for any apparatus and

experiments of this description, as results are more likely to be concordant, the conditions varying as little as possible.

had already been determined by Mr. Tate for the Sibpore apparatus by experiments made with cane sugar or other substances of known calorific value.

The following formula then gives the calorific power

$$C.P. = \frac{(T - t) \times (W + w)}{f} - r$$

where $C.P.$ is the calorific power.

T is corrected maximum temperature.

t is temperature at time of firing.

W is weight of water in grammes (2000).

w is water value of calorimeter.

f is weight of fuel in grammes.

r is calorific value of iron wire used in experiment.

The calorific value of iron wire being 1650 calories per gramme, and ·02 gramme being used for each experiment, the value of r would be 33 calories; as however about one-third of iron wire is never consumed, a mean value of 20 calories was deducted, which is correct to within a very few calories.

For an absolute result it would be necessary to weigh the unconsumed wire and make the necessary deduction for it, but this is for practical purposes an unnecessary refinement.

Fischer's calorimeter.—The author obtained a loan of this apparatus from the Geological Survey laboratory through the courtesy of Mr. T. D. LaTouche, Director, and Dr. W. A. K. Christie, Chemist of the Department. A complete description of the Calorimeter is to be found in Lunge's "Technical Methods of Chemical Analysis", page 251, from which the illustration in Fig. 3 is taken. It consists of a nickel-plated vessel for the water B which is contained in a wooden outer vessel D, the space between

B and D being loosely packed with dry swan's down. The combustion vessel is made of silver and is clipped to the bottom of the water vessel by means of three bent feet. The cover of this vessel has a tube (*a*) attached to it for the inlet of oxygen, and at the bottom of this tube is an arrangement for attaching the small cylindrical drum *pp*

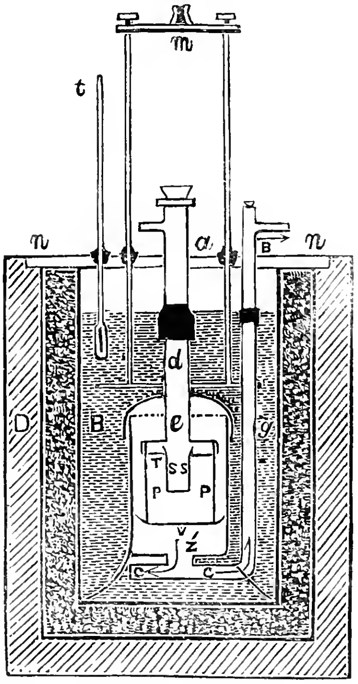

FIG. 3.—Fischer's Calorimeter. (Section.)

which contains a platinum gauze basket *ss* into which the weighed pellet of coal is placed. A special mould is supplied for making these pellets.

The cover forms a water-tight connection with the outer portion of the combustion vessel which rests on the bottom of the water container.

There is a silver tube *cc* running from the bottom of this combustion vessel through which the products of combustion have to pass; *m* is a stirrer and *t* a delicate thermometer; *n*, *n* are covers to fit over the top.

The weighed pellet of coal is inserted into the basket, and the small drum containing it is fixed to the cover of the combustion chamber. The cover is then firmly fixed to the body and the whole is let down into the water vessel, the feet being clipped to the bottom of it. 1500 grammes of water accurately weighed is transferred to the vessel; the covers with the stirrer placed in position and the thermometer inserted. Oxygen is turned on and readings taken in the same manner as with the Bomb. Ignition is started by means of a small splinter of wood or charcoal; this is not so satisfactory as electric ignition which the author tried to adapt to the apparatus, but practical difficulties prevented its adoption. To ensure complete combustion of the volatile portion of the coal it is necessary to run through oxygen under considerable pressure. The difficulty of procuring absolutely complete combustion of these volatile products and of preventing the formation of any trace of smoke is one of the greatest disadvantages of this calorimeter. If this could always be absolutely depended on results with this apparatus should be practically as good as those made with the Bomb.[1]

The coal is usually consumed within 5 minutes, and the water rises to its maximum in 10 minutes. Readings and corrections are made as before explained with the Mahler Bomb, and the calorific power calculated accordingly. The oxygen gas escaping from the calorimeter can

[1] Since this was written the author has successfully adapted electric ignition to the apparatus. This is a great improvement and renders results more accurate and concordant, the full pressure of gas being maintained from start to finish.

be recovered in a gas-holder after passing through a gas-washing bottle containing caustic potash.

The author made more extensive use of this calorimeter than of any other in fixing the calorific values of the different coal samples. It was accordingly necessary to obtain the water value of the apparatus in a manner which would admit of no doubt of its correctness.

This was accomplished by numerous experiments on pure sugar carbon which was taken to have a calorific value of 8080 calories. From the mean of six satisfactory determinations the water value of the calorimeter was determined at 150 grammes.

Taking this figure, a sample of coke obtained from the Westphalian coal was found to have a calorific value of 8200 calories, calculated free of ash. This value tallies with that obtained by Cox.

Thompson's calorimeter.—With this calorimeter the oxygen for combustion is produced by a mixture of nitrate and chlorate of potash. Very clear directions are given by the maker with the apparatus but a few hints, the result of many experiments, may not be amiss to those who wish to use this calorimeter.

Firstly, the coal being finely powdered should at once be transferred to a well corked bottle so that it may retain the original quantity of moisture and not alter by exposure to the atmosphere.

The necessary quantity of combustion mixture must then be weighed out and placed in a drying oven for at least an hour. It is most convenient to use 20 grammes of mixture for each combustion and to vary the weight of coal taken according to its character. This will be referred to later on at length.

It is most important, especially in a climate like

Calcutta, to have the mixture dead dry. It is a good plan to leave the weighed-out combustion mixture in the drying oven till the last moment before using.

Transfer it to a small wedgwood mortar, grind down any lumps to fine powder. Two grammes or less of the coal sample is weighed direct from the bottle on to a counterpoised watch glass in a chemical balance and carefully transferred to the mortar containing the combustion mixture and stirred up with it till thoroughly incorporated.

Place the copper cylindrical tube in which the combustion is to be made on a piece of glazed paper and carefully transfer the prepared mixture from the mortar to the tube with the aid of a spatula and camel-hair brush. In this way all loss can be avoided. The instructions given regarding temperature of water in the glass measure before commencing a combustion are hardly applicable to conditions in Calcutta except for a month or two of the cold season.

The temperature of the Assay Office laboratory from the beginning of March till the end of November varies between 29° and 33°-34° C.

The thermometer usually supplied with the apparatus only registers up to 35° C. For this country the thermometer should register several degrees higher.

The water should before commencing the combustion be about 3 degrees below room temperature. By keeping a supply in ordinary porous drinking vessels the right temperature can be obtained without much difficulty.

Tap water varies much in temperature, especially if the pipes are exposed to the sun in the daytime. It may often require cooling with ice to reduce it to the required temperature.

The glass measure is filled up to the mark 2000 cc.

This is of course very rough but is near enough for the degree of accuracy expected from the apparatus.[1] Having noted the temperature of the room, insert the thermometer, stir the water and read the temperature recorded. If it is not 2 or 3 degrees below the room temperature hot or cold water must be added till it attains this point, our aim being to finish off at a temperature as much above that of the room as we started below it, and thus minimize errors due to radiation of heat.

The fuse, which is best made by soaking some cotton wick strands in a saturated solution of lead nitrate, must be thoroughly dried before use. The temperature of the water is recorded just before the fuse is lit. The stop cock of the tube attached to the copper cover which is placed over the combustion cylinder must be closed before fixing this in its place.

It must be quickly adjusted between the clips directly the fuse is properly lighted.

The apparatus is inserted into the jar of water, combustion commencing directly the fuse has burnt down to the mixture.

The combustion should take about two minutes to complete. In conducting these experiments I found that with many coals a more complete combustion was obtained with the assistance of oxygen gas. It is often exceedingly difficult to burn off the whole of the carbonaceous matter with the combustion mixture alone. I consequently tried the experiment of passing a stream of oxygen gas through the combustion chamber from a gas-

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[1] The mark is adjusted for water at 15°C: it is consequently not quite correct for water at 26°—28°C, which is the usual temperature at which these experiments are made in Calcutta. It is well to weigh out 200 grms. of water at about 26°C and correct the mark accordingly.

holder. The gas-holder was connected by rubber tubing with a drying tower filled with calcium chloride, and from

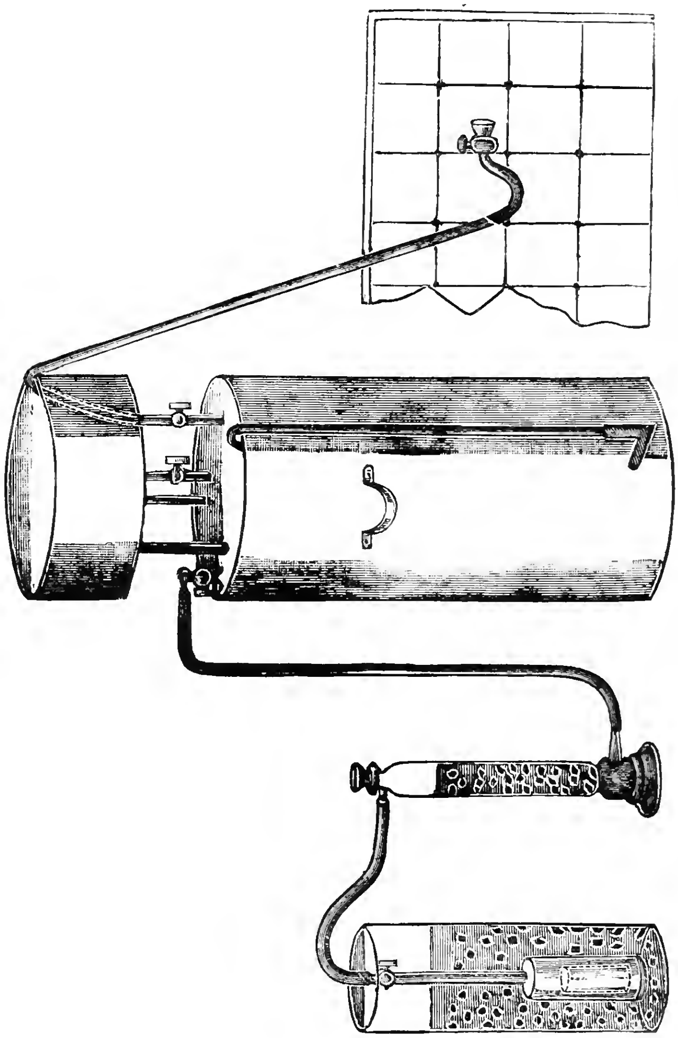

FIG. 4.—Lewis Thompson's Calorimeter. (Arrangement for working with Oxygen Gas.)

that by another rubber tube to the pipe of the combustion cylinder which was of course opened and not closed as in the ordinary experiments. See Fig. 4. It is necessary to have the oxygen under fairly high pressure to force it through the tube against the head of water in the vessel. This was accomplished by letting water into the gas-holder from the tap which connects with tanks on the roof of the building. After lighting the fuse the apparatus is inserted just below the level of the water and oxygen turned on. Combustion which is much more certain under these conditions begins almost at once, and the apparatus is then let down to the bottom of the vessel. It proceeds rapidly, and complete combustion of carbonaceous matter may be generally relied on. When conducted in the ordinary manner without the assistance of oxygen I found that coals high in fixed carbon such as the Westphalian and Scotch samples, also coals from Giridih and the more anthracitic varieties from the lower Barakur series such as Salanpur and some Jharia seams, gave a considerably lower value than when conducted as above.

By using oxygen gas results were obtained more closely approximating those worked out from Goutal's formula.[1] When the combustion is completed the stop cock is opened to let in the water, or if oxygen is being used the gas is turned off. Water at once rushes into the chamber. If, however, the hole is clogged up as is sometimes the case, it must be cleaned out with the brass pricker supplied with the apparatus. Lift the cylinder up and down a few times to mix the water and insert the thermometer. The latter will rise to its maximum reading in about one minute. This reading is recorded above the first reading. On subtracting one from the other

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[1] This formula is given later on in this paper.

the rise in temperature of the water is obtained. Ten per cent. has to be added for heat absorbed by the apparatus, etc., and the result multiplied by 1000 gives the calories when 2 grammes of fuel have been taken. When a lesser weight of fuel is used the calculation is quite simple. Thus on combustion of 1·7 grammes of Jharia coal difference of temperature registered was 5·6 degrees. Add 10 per cent. corrected difference equals 6·16 degrees. 1·7 grammes coal produces 6160 calories. Therefore 2 grammes coal will produce $\frac{6160 \times 2}{1 \cdot 7} = 7247$ calories. Divide the number by 537 the latent heat of steam and we obtain the number of pounds of water evaporated by one pound of fuel, *viz.*, 13·5.

Taking 20 grammes of combustion mixture the quantity of coal which should be used will depend on the proportion of ash and fixed carbon it contains. If high in ash a larger quantity of coal should be taken and if high in fixed carbon the proportion of combustion mixture must be increased, *i.e.*, the quantity of coal lessened. With Ranigunge (upper series) coals 2 grammes coal to 20 grammes mixture give good results if percentage of ash is not too high. With Giridih and Jharia coals containing 10 per cent. or less ash, I found 1·5 to 1·8 grammes coal to 20 grammes mixture satisfactory. Where ash is high the quantity of coal must of course be increased.

By keeping the quantity of combustion mixture constant, the cylinder can always be filled up to the same point, *viz.*, about ½ inch from the top.

Coke can only be tested with this apparatus by mixing it with a proportion of bituminous coal of known calorific value. The author did not find coke estimations at all reliable with this calorimeter.

SOME NOTES ON PREVIOUS LITERATURE.

Before proceeding any further, the author would like to make some reference to previous work done on Indian coals, more especially to literature which bears directly on the subject of this paper, *viz.*, proximate analyses and determinations of calorific power.

Literature on the subject of Indian coals, their analyses and calorific power, seems rather scanty. A paper entitled "Analyses of Ranigunge Coals" by A. Tween appeared in the Records of the Geological Survey of India in August 1877. Unfortunately though giving both proximate and ultimate analyses of 31 samples of coals mostly belonging to the Upper series, no calorific values are given; the workings must have been much shallower at that time than they are now, and examination of the list leads me to think that a generally higher grade of coal is won at the present time, as the lowest percentage of ash recorded is 12·1 whereas some samples carried over 24 per cent. I fancy such coal would hardly be marketable at the present day.

The next publication on the subject which the author has found is the paper entitled "Report on the Coal Supply of India" by Professor W. R. Dunstan, F.R.S., which appeared in the Agricultural Ledger in 1898. In this article a list of 53 Indian coals is given with their proximate analyses and calorific power as determined by "Thompson's" Calorimeter. In Table I, Appendix I, of this paper, a selection of seven coals has been made from the list and their calorific powers worked out by the formula proposed by Goutal. Unfortunately the chemist who carried out these analyses omitted to estimate the moisture in the different samples, but included it as volatile matter with the gaseous products driven off in the process of coking; *vide* p. 13 of Report (Appendix I).

In order to make the necessary calculations the quantity of moisture has to be assumed, and it was taken as about 0·8 per cent. for Giridih coals, 1·5 per cent. for Jharia coals and 3 per cent. for Ranigunge (Jyramdunga), being roughly the amount which these coals have been found to contain under usual conditions by the author.

A very cursory examination of this list calls forth some criticism of the manner in which these determinations were made and reported.

To begin with, to omit moisture from a proximate analysis and to combine it with volatile combustible matter is obviously misleading and inaccurate, as moisture is a deleterious ingredient in coals and the volatile combustible matter a most useful constituent of the same.

Some coals may have over 10 per cent. of moisture and to omit this item at once vitiates the entire analysis.

Then we find on examination that the calorific values vary in a most remarkable manner from what one would expect them to be judging from the analyses given. The seven coals extracted from the list are taken more or less haphazard; they happen to be from seams which the author has analysed, the nature of which he is fairly familiar with.

Take No. 636 the first on the table. It has 10·77 per cent. of ash, 56·45 per cent. of fixed carbon and 32·78 per cent. of volatile matter, of which we may assume 0·78 per cent. is moisture (the author found less than 1 per cent. moisture in the Giridih seams). Its calorific power is given as 7040 calories; yet looking at No. 3 on the list (Invoice No. 641) we find a coal with only 5·35 per cent ash, 66·8 per cent. fixed carbon and allowing ·83 for moisture, 27 per cent. of volatile combustible matter which is given a calorific value of 6985 calories only. Obviously we should expect No. 2 containing much less ash, more fixed carbon and a lower percentage of volatile constituents to have a considerably higher calorific power than No. 1. It is however given a lower value.

Then again compare analysis of No. 3 in Table I taken from Dunstan's report with No. 30 Giridih (E. I. Railway Colliery) in Table IV as made by the author.

These two coals approximate very closely in their important constituents as is shown below.

Description.	Moisture.	Volatile combustible.	Fixed carbon.	Ash.	Calorific power.		
					Calculated.	Bomb.	Reported.
Coal No. 3, Table I, E.I.Ry. Colliery.	27·85		66·80	5·35	8015		6985
Coal No. 30, Table IV, Giridih, E.I.Ry. Colliery.	0·4	26·24	67·61	5·75	8064	7885	7885

Although the calculated values of these two coals only differ very slightly, the calorific power as estimated by Mahler Bomb is 7885 calories against 6985 as determined with Thompson's calorimeter; *vide* Dunstan's report. Similar remarks apply to a comparison between coals Nos. 3 and 4 on the list (Table I).

The only possible explanation which the author can offer for these discrepancies is, that the determinations given in Dunstan's report were made with a Thompson's calorimeter in the ordinary way, which in the case of high carbon coals is unreliable. It was for this reason that the author modified his methods of working the Thompson's apparatus by means of which results approximating those of the bomb calorimeter and those calculated from the formula can be secured.

No further apology appears necessary for a paper dealing with calorific power of Indian coals and the proper interpretation of analyses for the purpose of deducing from them their correct heating values.

The only other published information on Indian coals which the author has been able to discover is a list of assays of Raniganj coals made by Dr. W. Saise and published in the Records of the Geological Survey of India, 1904.

Calorific values are not given, but the proximate analyses of seams such as Dishergarh, Jyramdanga, Shibpore, etc., tally very closely with results given in this paper, showing that the quality of these seams varies very little.

Dr. Saise does not give any analyses of Jharia or Giridih seams.

Table V, Appendix, gives a comparative list of assays made by the author and by Dr. Saise.

DEDUCTION OF CALORIFIC POWER BY MEANS OF GOUTAL'S FORMULA.

I will now pass on to an explanation of Goutal's formula as modified by Cox. Goutal in 1896 first showed that the calorific value of a coal could be determined with sufficient accuracy for industrial purposes from the proximate analysis. He extended his investigations later on to more than six hundred anthracitic and bituminous coals. Much of course depends on the class of coal which is being tested. Goutal worked it out originally for coking coals and Cox extended its application to Philippine coals which have a high percentage of moisture and volatile matter.

Comparisons between results obtained with a calorimeter and calculated results show that it can be usefully applied to Bengal coals.

Goutal's formula is as follows:—

P = 82 C + a V when

P = heating power in calories ;

C = percentage of fixed carbon in the coal ;

V = percentage of volatile combustible matter ;

a = function of the ratios between the volatile combustible and total combustible matter in the coal, *i.e.*, $\frac{V}{V + C}$, or taken as a percentage ratio $\frac{100 V}{V + C}$.

When $\frac{100 V}{V + C}$	is equal to		25	then (a)	is equal	to	102
,,	,,	,,	27·5	,,	,,	,,	97
,,	,,	,,	30	,,	,,	,,	92
,,	,,	,,	32·5	,,	,,	,,	87
,,	,,	,,	35	,,	,,	,,	82
,,	,,	,,	37·5	,,	,,	,,	77
,,	,,	,,	40	,,	,,	,,	72
,,	,,	,,	42·5	,,	,,	,,	67
,,	,,	,,	45	,,	,,	,,	63
,,	,,	,,	47·5	,,	,,	,,	59
,,	,,	,,	50	,,	,,	,,	58

Figure 5 is a graph by reference to which the value of (a) can at once be read off when $\frac{100 V}{V + C}$ has been calculated. It may be noted here that this factor represents the percentage of volatile combustible matter in the pure coal, ash and moisture being deducted.

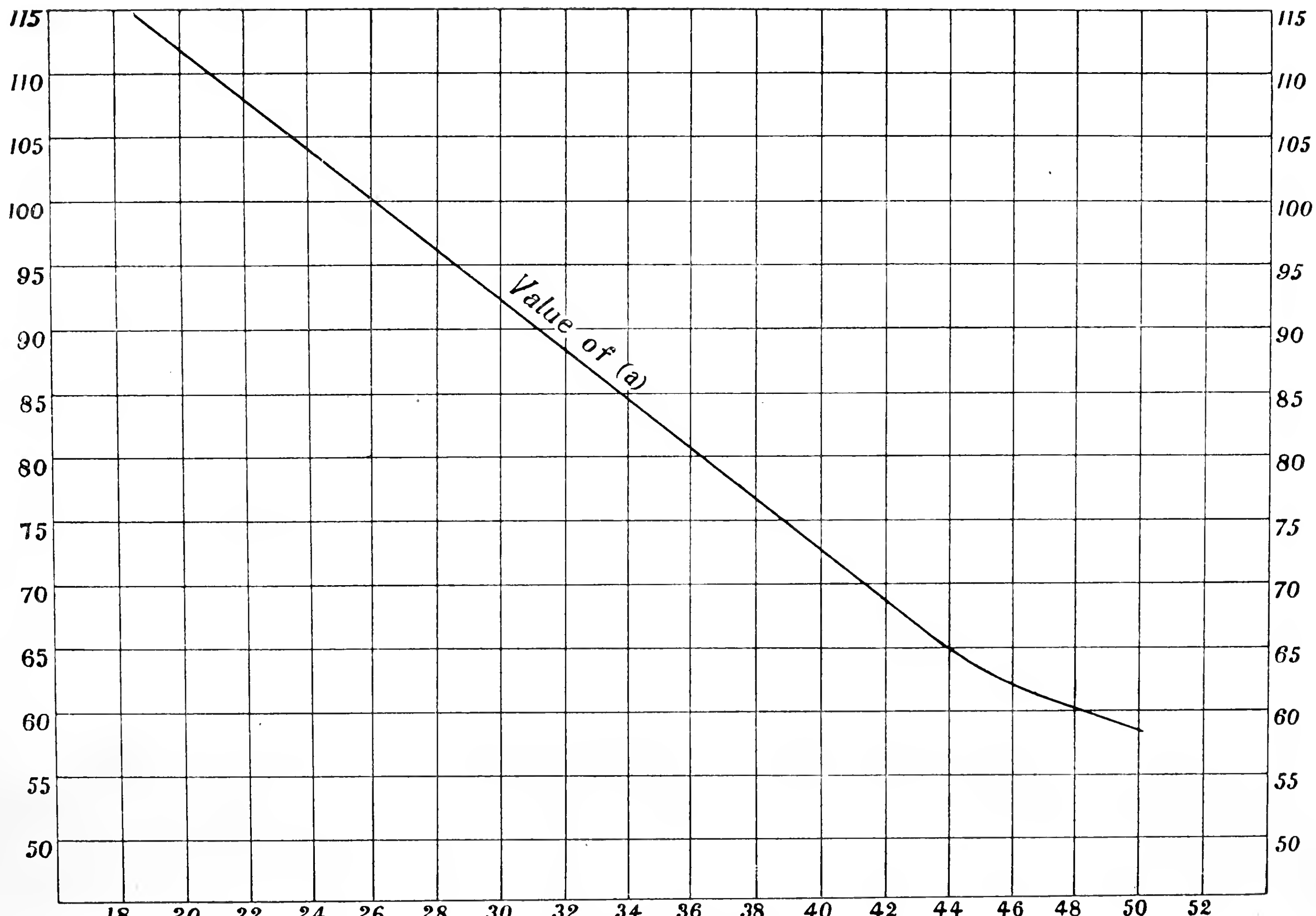

FIG. 5.—Value of 100 V

The method of using the formula is best shown by an illustration.

A sample of Australian coal has the following analysis :—

Moisture	..	2·59 %	
Volatile combustible		32·85 %	= V
Fixed Carbon	..	52·97 %	= C
Ash ..	..	11·59 %	
		100.00	

First calculate value of $\frac{100\ V}{V + C}$.

$$V = 32{\cdot}85$$
$$C = 52{\cdot}97$$
$$\therefore\ V + C = 85{\cdot}82$$
$$\frac{100\ V}{V + C} = \frac{3285}{85{\cdot}82} = 38{\cdot}3$$

Referring to figure 5. Follow up the ordinate 38·3 till it cuts the line of curve, we find value of "a" to be 75·5.

Referring to formula

$$P = 82\ C + a\ V = 82 \times 52{\cdot}97 + 75{\cdot}5 \times 32{\cdot}85$$
$$= 6822 \text{ calories.}$$ By calorimeter 6637 calories.

Applying the formula to a well-known Indian coal (Dishergarh) which had the following analysis :—

Moisture	..	3·25 %	
Volatile combustible		35·03 %	V
Fixed Carbon	..	53·22 %	C
Ash ..	..	8·50 %	

$$\frac{100\ V}{V + C} = \frac{3503}{88.25} = 39{\cdot}7 \qquad a = 73 \text{ nearly.}$$
$$P = 82\ C + a\ V = 82 \times 53{\cdot}22 + 73 \times 35{\cdot}03$$
$$= 6921 \text{ calories.}$$

By Mahler Bomb Calorimeter this coal has a calorific power of 7008 calories.

It will be seen that the above formula gives a variable value to the volatile carbonaceous matter in the coal and a fixed value to the carbon which is present in the fixed state. The accuracy of the formula will almost entirely depend on the correctness of the value deduced for the factor (a). Bengal coals being of much the same class of bituminous coals as those from which Goutal deduced his formula, we might reasonably expect it to apply to them.

When ultimate analyses have been made the heating effect can be determined with the greatest accuracy from the formula of Dulong.

$$C\ P = 8080\ C + 34{,}460\ (H - \tfrac{1}{8}\ O) + 2250\ S$$

when C P = calorific power in calories per kilogram.[1]

A table is given in the report of the Committee on coal analysis which was published in the Journal of the American Chemical Society in December 1899, page 1180, which shows that results obtained by the bomb calorimeter and the above formula are practically identical. This necessitates a very accurate ultimate analysis with correct percentages of carbon, hydrogen, oxygen, nitrogen and sulphur; and hardly affects the value of a formula which will give us an accurate idea of the calorific power of the coal from its proximate analysis only.

The calorific power of fixed carbon varies little in

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[1] This formula as also the formula of Goutal gives results for coal burnt to liquid water. As this is also the case with the Bomb and Fischer's calorimeters, it is the usual method of reporting calorific values.

Engineers and others will, of course, understand that the heating effect when stated in this manner includes about 4% of heat which can never be secured under practical conditions.

different coals. Goutal takes it at 8200 calories. This it will be seen is slightly higher than the calorific value of pure carbon which is given by the best authorities as 8080 calories. The reason of this discrepancy is that coke contains a small percentage of hydrocarbons which remain combined in the cementing matter in the process of coking and have a much higher calorific value than pure carbon owing to the hydrogen contained in them.

The actual calorific value of the fixed carbon in two samples of Australian coke is given by Cox in his paper already referred to as 8209 and 8224 calories respectively.

This explains why the factor 82 has been chosen for fixed carbon in the formula and not 80 or 81.

The factor (a) appears a very empirical one but has been deduced after very thorough study of the conditions affecting the calorific power of the volatile matter in coals.

It was worked out from the study of 150 samples of American coals by Cox, and the values differ somewhat from those given by Goutal. In this paper Cox's values have been taken.

In Table II (Appendix) the author has worked out from the formula the calorific power of 12 samples of American coals, selected from the U.S. Geological Survey Records of which the proximate analyses and calorific power as estimated by the Mahler Bomb had already been given.[1] It will be seen that the values obtained from the formula are with two exceptions lower than those given by the calorimeter but are close approximations. Table III (Appendix) is taken from Cox's paper and gives actual and calculated values of 10 samples of Australian coals.

[1] U. S. Geological Survey Records, 1909, Bulletin 382.

These coals bear a striking resemblance to those from our Indian seams.

Table IV[1] (Appendix) gives the results of the author's investigations on Indian and foreign coals of which he has succeeded in obtaining samples. The list does not pretend to be anything like exhaustive. Very many seams and even some whole districts are omitted; the author was, however, anxious not to delay too long in bringing out the paper as the list can always be added to later on, and other workers may be ready to supplement it and test the formula for coals of other districts as well as of seams not included in this list. The source from which samples were procured is given in the column of remarks in the table.

The most important results and those on which the general accuracy of the work done may be said to hinge, are the determinations made at the Sibpore College with the Mahler Bomb calorimeter.

The water value of this apparatus has been accurately worked out by Mr. Tate, and his value was taken by me as correct.

The coals tested were the following :—

1. Giridih (Lower seam) E. I. Railway Colliery.
2. Dishergarh (Equitable).
3. Shibpore seam (Banksimulla Colliery).
4. Salanpur (Heilger's Anthracite).[2]
5. 17 Seam Jharria.

A reference to Table IV (Appendix) will show the results obtained by different calorimeters and by calculation. The Mahler Bomb results were obtained from

[1] This table has been amended and revised since it was first published, as the result of subsequent experiments and investigations.

[2] Not a true anthracite but a bituminous coal anthracitic in character and high in fixed carbon.

experiments carried out in duplicate and triplicate, thus—

Three experiments on No. 1 Giridih coal gave the following figures :—7860, 7882, 7913 ; mean value 7885.

Two on No. 2 Dishergarh gave 7016 and 7000, mean 7008.

Two on No. 3 Shibpore seam gave 6808 and 6783, mean 6795.

Two on No. 4 Salanpur gave 7524 and 7488, mean 7506.

Two on 17 seam gave 7107 and 7144, mean 7125.

Values obtained with different calorimeters are given under different columns and can be readily compared.

As I stated before in this paper, it is sometimes difficult to obtain a perfect combustion free from all traces of smoke or unburnt carbon when using the Fischer calorimeter. This applies more particularly to coals high in volatile matter and moisture.[1] Taken all round, however, it is after the bomb by far the most satisfactory type, and its results can be relied on as accurate within a reasonable margin of error.

On scrutinizing the list in Table IV it will be seen that calculated values as a rule approximate closely to those obtained with a calorimeter. In fact calorimeters will themselves give very variable values, unless all conditions are minutely attended to, and many corrections made. The results obtained by one calorimeter will also differ from those obtained with another in a manner which is difficult to account for.

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1 This difficulty has been overcome by adapting electrical ignition to the apparatus, and by getting the oxygen under sufficient pressure at the start.

The author's experiments lead him to affirm what Cox has already stated in his paper on Philippine coals, that the calorific value obtained by calculation with Goutal's formula is as likely to be correct as an ordinary calorimetric test, unless the latter be made with a bomb or other reliable calorimeter under conditions which can only be obtained in a well-equipped laboratory.

A few rather unaccountable variations are to be noted such as the case of sample No. 53 (Heilger's Anthracite), where the calculated value is about 5 % higher than the actual value.

In a formula of this description which cannot take every constituent of a coal into account, such divergencies must be expected.

The heating value of the volatile portion of the coal depends largely and even principally on the amount of oxygen it contains. This is shown by recent investigations of the U. S. Geological Survey.[1] . In this pamphlet it is shown that oxygen and ash have an almost equally deleterious effect on calorific value. The oxygen is partly contained in the moisture of the coal and partly as a constituent of the volatile combustible matter. The greater the percentage of oxygen in the volatile combustible matter, the lower calorific power have those gaseous constituents. Goutal's formula is based on this assumption as the higher the percentage of volatile matter in the coal the lower does its calorific power become, and the lower the value of the factor "a." This is undoubtedly due to the fact that coals such as lignites of recent origin have not been deoxygenated to the same extent as coals of a greater age, which in losing their volatile constituents

1 U. S. Geological Survey Records, Bulletin 382. "The effect of oxgyen in coal" by David White.

in the gradual process of anthracitation at the same time part with a larger proportion of their combined oxygen.

By the process of weathering which may take place either in seams near the surface or after the coal is mined, oxygenation again begins and the calorific power of the volatile constituents is again impaired. Much useful research might be done by comparing the calorific power of coal obtained near the surface with that of coal from deep workings where there has been no possibility of weathering.

Some of the samples, more particularly of low grade coals, have a lower calorific value than they should have according to the formula. This may be partly accounted for by the fact that nearly all this coal is won from shallow depths and has suffered more or less from oxidation by weathering. The formula applies most strictly to freshly won unweathered coal.[1]

The sample of Dishergarh coal taken from a bore hole 1940 feet deep gives a calorific power well over the calculated amount. Giridih coal also proves the formula for Indian coals while in many other cases there is a close approximation in values. As regards the practical application of the figures obtained, it is generally known that a high percentage of moisture is detrimental to the calorific power of the fuel, as it has first to be evaporated to steam, thereby using up calories which would otherwise be usefully employed.

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[1] Another reason for the discrepancy may lie in the constitution of the ash or non-combustible portion of the coal.

Under the conditions of incineration, volatile matter which properly belongs to the ashy and non-combustible portion of the coal is driven off, and is thus included in a proximate analysis with the Fixed carbon.

Ash is obnoxious for reasons well understood by coal users, but in a determination of calorific power it is simply treated as so much inert material. Practically its presence lowers the heat value of the combustible portion of the fuel, as when falling out hot from the fire-bars it carries away a certain amount of heat which is lost. In clinkering it is also apt to include particles of carbon which are thereby unburnt, and thus complete combustion of the carbonaceous matter is prevented. In considering the practical application of the theoretical calorific value of the fuel these points must be carefully considered and due allowance made for them.

In this connection also the following remarks extracted from an article entitled "The Influences of the Volatile Constituents in Coal Combustion," which appeared in "Engineering,"[1] will be of interest:—

"Many researches on the combustion of coal conducted by different investigators in various countries have established the fact that coals containing about 20 per cent of volatile constituents yield the highest temperature and the best thermal efficiencies.

"The volatile constituents are calculated on the weight of combustible matter, and it would appear that the best results are obtained when the percentage of volatile constituents ranges from 16 to 23. Most of these results are based on perfect combustion tests conducted either in a calorimetric bomb or in a gas calorimeter of the Junkers type with the aid of an excess of air.[2]

"But perfect combustion cannot be realized in a boiler furnace, and the combustion takes place under different conditions moreover.

"The coal put on by the stokers undergoes, in the first instance, a kind of destructive distillation; gases are generated and burned before

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1 *Engineering*, July 15, 1910, page 93.

2 The author was not aware that this type of calorimeter was adapted to coal determinations. The Bomb calorimeter is now acknowledged as the standard type.

the resulting coke is itself burned. When the coal is rich in carbon and poor in volatile constituents, a great excess of air is required to ensure complete combustion of the coke, and much of the heat produced escapes with the excess of hot air.

" When the coal is rich in gas, some of the gas escapes before it is burned. Technically we have to strive at making the combustion as complete as possible, while avoiding excess of air. This consideration would tend to show that a coal which gives satisfaction in the calorimeter, because it contains a moderate amount of gaseous constituents, should also give satisfaction in practice. This conclusion is on the whole confirmed once more by some extensive and most careful practical tests, conducted by Professor E. J. Constam and Dr. P. Schlapfer, and described at length in the *Zeitschrfit des Vereines Deutcher Ingenieure* of November 1909."

The experiments are described at length in the article, and the deductions made therefrom will be interesting to Indian coal-shippers and consumers.

"Summing up from the commercial point of view, Professor Constam remarks that in countries like Switzerland and Northern Italy, in which coal is expensive owing to transport difficulties, short-flame coal of the highest calorific value, containing 16 to 23 per cent of volatile constituents, will prove most economical, because it does not pay to transport ashes and volatile matter which will escape unburnt. Long-flame coal will on the other hand answer in internal furnace boilers, if the steam production must occasionally be rapid."

It certainly appears to the author that in specifications by large coal consumers for fuel required for raising steam, where the value of the fuel depends on its heating power, a basis for sale and purchase of the coal might well be arranged on proximate analyses and on the calorific power deduced therefrom. Where samples are properly taken in the presence of parties representing both buyer and seller, and these samples after being quartered down, crushed to appropriate size, and sealed up, are submitted to properly qualified analysts, a fair and just valuation for the coal can be rapidly arrived at.

For a first class steam coal the author considers the following as a reasonable specification which could be modified according to the class of boilers or furnaces for which the fuel is required, some requiring an easy free burning coal fairly high in volatile matter which does not require an excessive draft, others preferring a more anthracitic variety.

1. *Ash in the dry coal not to exceed* 15 *per cent.* The U.S. Government base their specifications on dry coal,[1] *i.e.*, coal free from moisture as determined by drying a small sample at 105°C. It is obvious that the percentage of ash in dry coal will always be somewhat higher than in the undried sample. This method of calculation puts all coals on a fair and even basis of comparison as regards their ash contents, and no coal containing more than 15 per cent. ash in the dried sample could well be classed as first class. The percentage might, however, be increased for rubble, slack and dust, but for large steam coal 15 per cent. appears a good and even high maximum for ash.

2. *Calorific power as estimated by bomb calorimeter, or where this form of calorimeter is not available from Goutal's formula based on proximate analysis to be not less than* 6500 *calories equivalent to* 11,700 *B.Th.U.*[2]

It will be seen that coals having the following analyses would just come within this category :—

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1 U. S. Geological Survey. Bulletin 378 of 11.

2 The Fischer calorimeter with electrical ignition can be made to give results which are practically as reliable and concordant as the Bomb. It has the additional advantage of not requiring oxygen under high pressure for its working, and might be included with the Bomb in above definition.

(1)

Moisture	5 %	
Volatile combustible	35 %	
Fixed carbon ..	50 %	
Ash ..	10 %	on dry coal basis 10·53 %
	100 %	

Working this out by Goutal's formula we get

$\frac{100V}{V + C} = 41{\cdot}2$, a = 70, Calorific power = 6550.

(2)

Moisture	1 %	
Volatile combustible	25 %	
Fixed carbon ..	60 %	
Ash	14 %	on dry coal basis 14·15 %
	100 %	

Working this out by Goutal's formula we get

$\frac{100V}{V + C} = 29{\cdot}4$, a = 93, Calorific power = 7245.

It will be noted that No. 1 is a typical (Ranigunge) upper series coal and No. 2 a typical lower series (Burrakar or Jharia) coal.

Although the calorific power of No. 2 is high, its high ash percentage detracts considerably from its value; for this reason it is absolutely necessary to have a maximum ash limit as well as a minimum for calorific power in any specification.

As regards the analyses given in the appended tables, the author wishes it to be clearly understood that he does not pretend that the samples analysed are absolutely representative of the seams from which they were taken. Indian seams vary in quality in different parts and their ash contents depend largely on the bands of shaley matter or intrusions of burnt coal or "jama" which they contain. Bulk samples would probably give higher percentages of ash than those shown, as the samples tested are of the clean coal free from shaley bands. By the courtesy of the Managing Agents of several coal companies I have obtained samples which may be considered representative of the seams being worked, but I wish it to be clearly understood that the list is by no means complete and that my results are obtained from hand samples[1] only and should not be given a commercial value they may not possess.

From the analyses, however, the general character of the coals from different seams can be seen. There are certain characteristics which belong to certain seams and certain districts, and these show up clearly in the tables. One point which must strike an observer when glancing through the tables is that the lower we descend in the Geological series the more anthracitic do the coals become, *i.e*, higher in fixed carbon and lower in moisture and volatile matter. Leaving ash contents out of consideration we find that the upper seams are high in moisture and volatile matter, while the lower seams are high in fixed carbon and low in moisture and volatiles, which is exactly what we should be led to expect. Thus a pretty accurate idea of the position of an Indian coal in the Geological series can be arrived at from its proximate analysis.

In conclusion, I have to record my thanks for the kind assistance received from Managing Agents and others who sent samples of coal for testing, and to Mr. G. O. L.

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1 There are some exceptions to this as indicated in the column of remarks, Table IV.

Durham, 2nd Assistant in the Assay Office laboratory, who executed drawings of the figures in this paper and rendered valuable aid in my work at Sibpore College and in our own laboratory.

APPENDIX I.

TABLE I.

Extract from Table II of Dunstan's "Report on the Coal Supply of India" with calorific values as calculated by Goutal's formula.

No.	Invoice number.	Imperial Inst. number.	Mine and source whence received.	Volatile matter including moisture.	Fixed carbon.	Ash.	Calories as given in list.	Calculated calories.
1	636	1980	Kaharbari [Giridih] E. I. Railway Colliery.	32·78	56·45	10·77	7040	7189
2	639	1983	Do., Lower Seam ..	27·83	64·80	7·37	6644	7824
3	641	1985	Do., Upper Seam ..	27·85	66·80	5·35	6985	8015
4	6817	7070	Giridih Steam Coal. Superintendent, Bengal Coal Co.	29·08	60·93	9·99	7183	7464
5	8081	7453	Jyramdunga. Managing Agents, New Birbhoom Coal Co.	38·03	51·36	10·61	6809	6696
6	8196	7772	Choitodee. Katras No. 15 Seam	27·30	61·24	11·46	6787	7422
7	8329	7776	Kustore. Raniguuge Coal Association.	27·71	53·71	8·58	6666	7687

TABLE II.—AMERICAN COALS.

According to analyses made by U. S. Geological Survey (vide *Bulletin* 382).

No.	Description of Coal.	Moisture.	Volatile combustible.	Fixed carbon.	Ash.	Sulphur.	Value of $\frac{100\ V}{V+C}$	Value of *a*.	Calorific Power.	
									Calculated.	Mahler Bomb.
1	No. 127 Ill. 12 D. Bush . . .	2·97	32·51	53·54	10·98	2·70	37·8	76	6855	6910
2	,, 134 Ala 3 Garnsey	1·54	29·82	54·11	14·53	0·56	35·5	81	7119	7007
3	,, 139 Ill. 16. Herrin	4·61	31·35	54·05	10·00	1·19	36·7	78	6907	6921
4	,, 151 Tenn. 9A. Coalmont . .	1·36	27·06	56·22	14·46	0·96	33·2	86	7012	7135
5	,, 176 Pa. 17. White	1·09	28·71	57·87	12·31	1·56	33·2	86	7212	7448
6	,, 180 Ky. 8. Sturgis . .	2·33	32·01	57·48	8·18	1·22	33·2	86	7466	7598
7	,, 193 Pa. 7. Ligonier . .	0·92	21·30	64·90	12·88	2·15	24·7	102	7494	7549
8	,, 210 Va. 6. Richlands	0·65	24·28	64·77	10·30	1·27	27·3	97	7664	7757
9	,, 225 W. Va 17. Near Bretz . .	1·00	27·99	62·68	8·33	1·40	30·9	90	7658	7903
10	,, 240 W. Va. 7. Sun	0·76	20·54	73·61	5·09	1·20	21·8	108	8254	8254
11	,, 248 W. Va. 6. Rush Run . .	0·64	21·74	72·53	5·09	0·66	23·0	106	8247	8301
12	,, 250 W. Va. 10. Mora	0·65	18·80	75·92	4·63	0·57	19·8	112	8327	8439

TABLE III.

Australian Coals from Cox's paper in Philippine Journal of Science.

No.	Source.	Moisture.	Volatile combustible.	Fixed carbon.	Ash.	Sulphur.	Value of $\frac{100\ V}{V+C}$	Value of *a*.	Calorific Power. Calculated.	Calorific Power. Calorimeter.
1	West wald send (1905) ..	2·59	32·85	52·97	11 59	....	38·3	75	6775	6637
2	Ditto (1906) ..	2·60	34·84	52·57	9·99	0·01	39·9	72	6825	6976
3	Ditto	2·44	34·77	45·18	11·61	0·61	43·6	66	0000	6128
4	Ditto (1907) ..	2·80	24·23	50·94	12·03	0·09	40·2	72	6600	6614
5	Ditto (1908)[a] ..	1·74	36·64	52·43	9·19	0·15	41·1	70	6875	6983
6	Ditto (1907)[b] ..	2·56	32·97	51·68	12·79	0·12	38·9	78	6650	6472
7	Ditto (1908) ..	2·80	31·24	54·35	11·61	....	36·5	79	6920	6835
8	New West wald send (1907) ..	2·56	35·28	52·46	9·70	0·31	40·2	72	6825	6906
9	Illawarra near Sydney ..	1·26	25·26	63·49	9·99	....	28·5	95	7600	7624
10	Lichzow Valley (1908) ..	2·11	32·47	52·62	12·80	0·58	38·2	76	6770	6987

a. Selected lump.
b. Double screened and picked twice.

TABLE IV.—FOREIGN AND INDIAN COALS.

Analysed by the Author.

No.	Description.	Moisture.	Volatile combustible.	Fixed carbon.	Ash.	Sulphur.	Value of $\frac{100\ V}{V+C}$	Value of a.	Calorific power. Calculated.	Thompson's Calorimeter.	Fischer's Calorimeter.	Bomb Calorimeter.	Remarks.
	Foreign Coals.												
1	Natal	3·45	29·87	57·46	9·22	0·73	34·2	83	7218	7040	7130	..	Given by Mr. J. H. Rayneau from bunkers of S.S. "Bueeros."
2	Japanese	3·60	35·21	53·69	7·50	..	39·6	73	6972	7040	7115	..	By Mr. Agabeg from bunkers of Apcar Liner.
3	Welsh Steam (bituminous) ..	4·00	34·73	58·84	2·43	..	32·5	86	7846	7600	7620	..	From Mr. J. H. Rayneau.
4	Westphalian	0·90	19·10	78·00	2·00	..	19·7	112	8535	8150	8405	..	Ditto.
5	Scotch Steam	4·20	21·80	70·80	3·20	..	23·6	104	8069	7760	7910	..	Ditto.
	Bengal Coals.												
	Raniganj [Upper Series].												
6	Dishergarh Seam [Equitable]	3·25	35·03	53·22	8·50	0·32	39·7	73	6921	7040	6950	7008	Taken at Pit mouth.
7	Do. [Nuni] ..	3·33	29·60	55·90	11·17	..	34·6	83	7040	..	6900	..	Ditto.

TABLE IV.—(*Continued*).

No.	Description.	Moisture.	Volatile combustible.	Fixed carbon.	Ash.	Sulphur.	Value of $\frac{100 V}{V+C}$	Value of a.	Caloric power. Calculated.	Thompson's Calorimeter.	Fischer's Calorimeter.	Bomb Calorimeter.	Remarks.
8	Dishergarh Seam [Nursamooda Colliery Bore hole 1,940 ft. deep].	1·97	32·37	53·69	11·97	..	37·6	77	6895	7150	7190	..	Sent by Messrs. Lyall, Marshall & Co.
9	Dishergarh Seam [Chowrassie]	3·06	30·96	53·08	12·90	..	36·8	78	6767	..	6705	..	,, Messrs. MacNeill & Co.
10	Do. [Saltore] ..	3·33	34·15	53·16	9·36	..	39·1	74	6886	..	7085	.	,, Messrs. Bird & Co
11	Jyramdunga Colliery ..	4·30	31·64	56·06	8·00	..	36·1	80	7128	6875	6970	..	Taken at Pit mouth.
12	Baraboni [Upper Seam] ..	3·04	31·96	54·10	10·90	..	37·2	78	6929	6800	..	..	Ditto.
13	Do. [Lower ,,] ..	2·40	32·44	56·06	9·10	0·52	36·6	79	7159	6930	6970	..	Ditto.
14	Poniata Seam [Apcar's] ..	4·66	29·52	57·32	8·50	..	34·0	84	7179	6930	6920	..	Sent by Mr. E. M. Patterson, Charanpore.
15	Do. [Bhuskajuri Colliery]	4·36	32·40	55·24	8·00	..	36·9	78	7056	..	6965	.	Sent by Messrs. Bird & Co
16	Bhuskajuri Colliery [Upper Seam].	3·70	32·64	51·93	11·73	..	38·6	74	6674	..	6660	..	Ditto.
17	Shibpore Seam	4·23	32·47	54·25	9·05	..	37·4	77	6948	..	6910	..	Sent by Mr. E. M. Patterson, Charanpore.
18	Do. [Banksimulla Colliery]	3·20	35·05	53·10	8·65	0·22	39·8	72	6778	..	6830	6795	Sent by Bengal Coal Co.
19	Do. [Jamuria] ..	5·18	32·52	54·26	8·04	..	37·4	78	6985	..	6930	..	,, Messrs. MacNeill & Co.

20	Charanpur [Upper Seam] ..	7·00	33·00	51·90	8·10	..	38·9	74	6698	6600	..	..	Sent by E. N. Forbes.
21	Satpukuria [4′ Seam] ..	6·10	32·75	50·85	10·30	0·41	39·2	74	6593	6545	6630	..	Taken at Pit mouth.
22	Nursamooda [4′ 6″ Seam] ..	5·37	30·63	51·92	12·08	..	37·1	78	6612	6400	6290	..	Ditto.
23	Benally	7·53	30·75	54·09	7·63	..	36·2	79	6863	..	6660	..	Sent by Messrs. N. C. Sircar & Son.
24	New Damra	6·35	32·46	53·19	8·00	..	37·8	76	6827	..	6680	..	Ditto.
25	Nimcha [Meyers] ..	6·45	33·38	49·13	11·04	..	40·4	71	6398	6380	..	..	,, Mr. L. Rayneau.
26	Do. [Barabom C. C.]	6·83	30·62	50·36	12·19	..	37·8	76	6457	..	6225		,, Messrs. N. C. Sircar & Son.
27	Haripore [Topsi Seam] ..	9·06	31·13	52·32	7·49	..	37·3	77	6581	..	6555	..	Ditto.
28	Bhatdee Colliery ..	1·44	31·33	57·23	10·00	..	35·4	81	7230	7200	7250	..	.. Messrs. A. Yule & Co.
29	Murlidih	1·93	29·88	57·29	10·90	..	34·3	83	7137	6930	7140	..	,, Bengal Coal Co.

N.B.—Nos. 28 and 29 are from the Upper (Raniganj) measures of the Jharia coalfield.

Barakar [Lower Series] includes Barakar, Giridih and Jharia measures.

30	Giridih [E. I. Ry. Collieries, Lower Seam].	0·40	26·24	67·61	5·75	0·40	28·0	96	8064	7640	7060	7885	Sent by Mr. G. C. Lathbury.
31	Kuldia	0·64	23·48	66·80	9·08	..	26·0	100	7825	..	7850	..	.. Bengal Coal Co.
32	7 Seam [Bansjorah] ..	0·90	15·60	59·15	24·35	0·32	20·9	110	6566	6013	6260	..	,, Mr. F. Agabeg.
33	10 ,, [Kasoonda] ..	1·53	16·00	63·35	18·52	..	20·7	110	7027	6722	6620	..	.. Mr. J. B. Wardlaw, Jharia.
34	11 ,, ..	0·79	21·39	60·30	17·43	..	26·2	99	7060	..	6950	..	Ditto.
35	12 ,, [,,] ..	1·06	19·45	64·35	15·14	..	23·2	105	7316	7063	..	..	Ditto.
36	12 or 13? Seam [Sudamdih] ..	1·20	25·23	66·91	6·66	..	27·4	97	7931	7600	7770	..	Sent by Mr. T. S. Gibson, Sudamdih.
37	13 Seam [Kurkhend] ..	0·92	21·18	67·00	10·90	..	24·0	104	7688	..	7485	..	,, Messrs. N. C. Sircar & Son.

TABLE IV.—(*Continued*).

No.	Description.	Moisture.	Volatile combustible.	Fixed carbon.	Ash.	Sulphur.	Value of 100 V / V+C	Value of a.	Calorific power. Calculated.	Thompson's calorimeter.	Fischer's calorimeter.	Bomb calorimeter.	Remarks.
38	14 Seam [Sudamdih] ..	1·60	29·10	61·10	8·10	..	32·2	87	7559	7480	..	..	Taken at Pit mouth.
39	14 ,, [Sijua]	1·21	23·19	68·48	7·12	0·64	25·3	101	7957	7700	..	..	Sent by Mr. J. B. Wardlaw.
40	14 ,, [Standard] ..	1·60	24·40	65·60	8·40	..	27·1	98	7760	7500	7500	..	,, Messrs. F. W. Heilgers & Co.
41	14 ,, [Sendra] ..	0·65	18·52	70·23	10·60	..	21·4	109	7772	7400	7400	..	Ditto.
42	14 ,, [Boraree] ..	0·94	23·86	66·06	9·14	..	26·5	99	7779	7300	7360	..	,, Mr. J. J. Turnbull, E. I. Coal Co.
43	14A ,, [Standard] ..	0·79	24·00	61·92	13·29	..	27·9	96	7381	..	7150	..	Sent by Messrs. F. W. Heilgers & Co.
44	14A ,, [Boraree] ..	1·00	24·60	61·75	12·65	..	28·5	95	7400	7120	7244	..	Sent by Mr. J. J. Turnbull, E. I. Coal Co.
45	15 ,, [Simla Behal] ..	1·08	17·49	68·68	12·75	0·57	20·3	111	7573	7200	7230	..	,, Mr. J. B. Wardlaw.
46	15 ,, [Bhulan boraree] ..	1·20	24·57	65·73	8·50	..	27·2	97	7773	7570	..	..	,, Messrs. F. W. Heilgers & Co.
47	15 ,, [Boraree] ..	1·13	25·23	66·74	6·90	..	27·4	97	7920	7700	7710	..	,, Mr. J. J. Turnbull, E. I. Coal Co.
48	16 ,, [Burragarh] ..	1·48	26·31	53·72	18·49	0·81	32·9	86	6667	6700	6600	..	,, Mr. J. B. Wardlaw.
49	16 ,, [Hurriladih] ..	1·87	25·20	62·58	10·35	..	28·7	94	7500	..	7310	..	,, Messrs. MacNeill & Co.

50	17 Seam [Burragarh] ..	1·57	25·74	61·18	11·15	0·73	29·6	92	7384	7100	7120	7125	Sent by Mr. J. B. Wardlaw.
51	17 ,, [Kendwadih] ..	2·18	26·51	63·26	8·05	..	29·5	92	7626	..	7420	..	,, Messrs. MacNeill & Co.
52	18 ,, ...	1·93	30·35	59·29	8·43	..	33·8	84	7411	7200	7275	..	,, Mr. J. B. Wardlaw.
53	Heilgers' Anthracite [Salanpur]	0·93	17·66	71·42	9·99	0·37	19·9	112	7834	7400	7430	7506	,, Messrs. F. W. Heilgers & Co.
54	Chanch [Barakar District] ..	2·11	27·80	61·02	9·07	..	31·3	89	7505	..	7450	..	,, Bengal Coal Co.
55	Jumoni [Katras ,,] ..	0·94	22·21	64·58	12·27	..	25·6	101	7532	..	7140	..	,, Messrs. Bird & Co.
56	Gourandi [Burrakar Coal Co.]	1·90	28·82	59·72	9·56	..	32·5	86	7375	..	7165	..	Ditto.
57	Rubble (N. C. Sircar & Co.) ..	0·93	27·46	57·87	13·74	..	32·2	87	7132	..	7190	..	Bulk samples received from H. M.'s Mint.
58	Steam Coal (do.) ..	1·13	26·36	64·56	7·95	..	29·0	94	7769	..	7595	..	Ditto.
59	Do. (Bird & Co.) ..	0·66	23·81	64·01	11·52	..	27·1	97	7558	..	7305	..	Ditto.
60	Do. (Balmer, Lawrie & Co.)	0·80	18·70	63·72	16·78	..	22·7	106	7206	..	7200	..	Ditto.
61	Rubble (Anderson, Wright & Co.)	1·49	21·04	63·56	13·91	..	24·8	102	7357	..	7210	..	Sample taken from deliveries actually being used for Mint Boilers.
	Central Provinces.												
62	Pench Valley (Barkni Seam)	11·51	27·76	47·31	13·42	..	36·9	78	6043	..	6050	..	Sent by Messrs. Shaw, Wallace & Co.
63	Do. (Chandametta Seam).	13·26	28·45	47·24	11·05	..	37·6	76	6034	..	5900	..	Ditto.
	Burma, S. Shan States.												
64	Outcrop Coal	4·67	35·20	52·98	7·15	..	39·9	72	6878	..	6760	..	Received from Mr. H. A. Pringle.

TABLE V.—COMPARATIVE ANALYSES OF RANIGUNJ COALS.

Taken from Dr. Saise's tables in Rec. Geol. Surv. Ind., Vol. XXXI, p. 104, and from the Author's analyses as given in Table IV of this paper.

Description.	Dr. Saise.					The Author.				
	Moisture.	Volatitle combus-tible.	Fixed carbon.	Ash.	Calcula-ted calories.	Moisture.	Volatile combus-tible.	Fixed carbon.	Ash.	Calcula-ted calories.
Haripur	9·05	32·95	49·58	8·52	6437	9·06	31·13	52·32	7·49	6581
Damra .. .	4·75	38·25	47·00	10·00	6864	6·35	32·40	53·19	8·00	6827
Baraboni	4·00	28·00	61·00	9·00	7466	2·40	32·44	56·06	9·10	7159
Jyramdunga	4·11	29·99	56·47	9·42	7088	4·30	31·64	56·06	8·10	7128
Shibpore	3·60	33·40	54·00	9·00	6933	4·23	32·47	54·25	9·05	6948
Dishergarh	2·80	33·77	53·08	10·35	6853	3·25	35·03	53·22	8·50	7040
Chanch	1·00	26·50	59·50	14·00	7254	2·11	27·80	61·02	9·07	7505
Gourandi (picked)	0·75	28·75	59·50	11·00	7351	1·90	28·82	59·72	9·56	7375

TABLE VI.

Ultimate analyses of typical Bengal Coals.

No.	Description.	1 Moisture H_2O.	2 Carbon.	3 Hydrogen.	4 Oxygen and Nitrogen.	5 Sulphur.	6 Ash.	7 Carbon in pure coal.*	8 Hydrogen in pure coal.	9 Calorific value (Bomb Calorimeter).	10 Calorific value deduced from ultimate analysis.	11 Calorific value from proximate analysis.	12 Calorific value of pure coal.
1	Giridih, E. I. Railway	0·40	80·07	4·92	8·46	0·40	5·75	85·78	5·27	7885	7815	8064	8403
2	Heilgers' Anthracite	0·93	78·45	4·35	5·91	0·37	9·99	88·06	4·88	7566	7577	7834	8426
3	17 Seam Jharia	1·57	72·63	4·77	9·15	0·73	11·15	82·73	5·43	7125	7149	7384	8200
4	Dishergarh	3·25	70·43	5·51	11·37	0·32	8·50	80·52	6·24	7008	7100	6921	7941
5	Shibpore (Banksimulla Colliery) ..	3·20	69·87	5·15	12·91	0·22	8·65	79·27	5·84	6795	6824	6778	7709

* *N.B.*—Pure coal is the total combustible matter in the coal after deducting moisture and ash. It is obtained as a percentage of the original coal by deducting the sum of percentages of moisture and ash from 100.

DISCUSSION.

The President said :—I think you will all agree with me that our thanks are due to Major Hughes for the valuable paper that he has read, and that we should feel grateful to him for the public spirit he has shown in devoting so much of his spare time to these experiments.

There are one or two points that have occurred to me during the reading of the paper which I should like to mention before opening the discussion. It is satisfactory to learn that the results of Major Hughes' experiments indicate that as the coal-fields are opened out and the seams are worked at greater depths the quality of the coal as regards its steam-raising properties is likely to improve. They also point to the danger of estimating the economic value of a new field by taking samples from the outcrops of the seams alone. But I am afraid that such experiments are not of much value in estimating the relative geological position of the seams or in correlating those of one area with another, for they would be largely discounted by the effect of atmospheric influences in the case of those that approach the surface.

I trust that these experiments of Major Hughes be pursued further. He has given us an excellent start, but he has been able to deal with a comparatively small number of samples only, and I am convinced that a more complete series of determinations, from samples taken from all the principal seams of the coal-fields, would not fail to be of great assistance to the industry, especially in the marketing of the coal. The new maps of the Ranigunj field prepared under the auspices of the Institute, which, as I am informed by my colleague Mr. Walker, is now approaching completion, will be of great use in such an enquiry in enabling the various seams to be correlated with each other, and a table of calorific values for each seam would be a most useful supplement to the maps.

Something more, however, is needed than results obtained as these are, by experiments on extremely small quantities of coal, and I should like to see an experimental station installed on the coal-field, equipped with suitable boilers and testing apparatus, in which the actual amount of work done by a given quantity of coal in bulk could be tested.

H. A. PRINGLE said:—I have listened with great interest to Major Hughes' paper and wish to associate myself most cordially with the Chairman's remark that he hoped Major Hughes would follow up this paper by another one dealing with the matter more exhaustively.

I am largely in agreement with Mr. Thomson that it seems impossible that a correct calorific value can be ascertained without having first analysed the coal for the constituent parts of its volatile matter. We must not however overlook the fact that Major Hughes' paper expressly deals with proximate analysis and its correlation with calories. I do not suppose that the author maintains that the application of a formula to proximate analyses can determine the calorific value with the same degree of accuracy that would result where an ultimate analysis had revealed the component parts of the volatile hydrocarbons. Major Hughes has told us that the formula used has been adopted only as the result of a very large number of experiments. I can quite believe it—but the chemical composition of the item "volatile matter" also ranges over a wide area and is capable of a multitude of chemical combinations. It would be of the greatest service to this

Institute if Major Hughes would carry his research still further, and by supplementing his paper provide us with a "standard work" on the subject. Personally, I fail to see how Goutal's formula can apply with equal accuracy to coals of the per-hydrous, ortho-hydrous and sub-hydrous type as compared with per-bituminous, ortho-bituminous, and sub-bituminous.

I should also like to see the investigation carried to the extent of a general comparison of results on unwashed and washed samples of coal. The difference, if any, of moisture as determined by Major Hughes' method and by the more sensitive means of drying in vacuo over sulphuric acid. In his second edition or supplementary edition I would suggest that the "classification" of coals under certain defined qualifications be fully investigated.

With regard to the author's comments on Professor Dunstan's "Report on the Coal Supply of India" he has apparently hit the nail on the head in discounting the accuracy of the Thomson calorimeter. Another eminent chemist, 'Clarence Seyler,' in his very valuable contribution to the records of the South Wales Institute in 1900 on the "Chemical Classification of Coals" also expresses the opinion that "Thomson's calorimeter, so often employed, cannot be considered as meeting modern demands."

The majority of us have but little time in the ordinary course of our work to devote to the subject in hand; it plays no prominent part in our technical training and is apt to be regarded as a matter for metallurgical people only. I do not hold with this view and fully appreciate the ease and simplicity of the methods described by Major Hughes—it brings within reach of those of us who lack the higher chemical knowledge a means of working out for ourselves at a minimum cost in apparatus and technical training--the volatile matter—moisture—ash and carbon in the coals with which we are in daily contact. Then, by the application of Goutal's formula we can arrive at the calorific value on lines more or less approaching accuracy. It provides us with an added interest in our work and enables us to discuss with greater effect the whole question of coal classification and calorific power. I consider the paper a most valuable addition to our records.

R. R. Simpson said:—Whilst unwilling to seem to decry the admirable conclusions drawn in the author's paper I feel bound to point out that many of the analyses give results discordant with the known selling value of the fuels. To some extent this may be due to variation in sampling methods, and I trust that if the author pursues his investigations he will take pains to have bulk samples taken by independent persons. Taking the analyses as a whole it seems to me that the ash content is from 20 to 50%, and in some cases 100% too low. The average Bengal coal does not contain less than 15% of ash. From the fact that the typical analyses instanced on page 149, and the author's tables, show that the average Jherria coal from the Barakar series is not less than 10% superior to coal from the Dishergarh seam in the Raniganj series, it is evident that analyses and calorimetric determinations have not the last word to say from the consumer's point of view, and there must be some vital factor of which laboratory tests do not take account. It is not unlikely that it is the free burning quality of Raniganj coals which commends its use to the consumer.

Major Hughes has referred to the advisability of selling coal by analysis and calorimetric determination. To some small extent this is already being done. At least one large contract is now running, by the terms of which fines are inflicted on a fixed scale if certain limits of fixed carbon and ash are departed from.

One of the speakers has expressed his opinion that tests should be made in locomotive boilers. Most of the Indian railways have already made such tests, and some years ago the North-Western Railway Company after a series of tests drew up a scale of values for coals from Bengal, Central Provinces, Central India, Hyderabad, the Punjab. The unit of value used was that of Welsh steam coal.

On page 151 the author states that "a pretty accurate idea of the position of an Indian coal in the Geological Series can be arrived at from its proximate analysis." I presume he does not intend this rule to have any wider application than the Bengal coal-fields. It certainly cannot be applied to the tertiary coals from the Punjab, Baluchistan, Assam and Bikanir, etc.

Major Hughes has complained of the lack of published analyses of Indian coal, but he has apparently not exhausted all the sources of information, for I have myself published in the "Memoirs" and "Records" of the Geological Survey of India probably not less than two or three hundred proximate analyses of Indian tertiary coals. Many of these are accompanied by calorimetrical determinations made with Thomson's appliance.

THE AUTHOR contributed the following reply to the discussion in writing :—

It is very gratifying to feel that my modest efforts have met with such a very kind reception from the members of the Institute.

The results tabulated in the paper have entailed a very considerable amount of work, which has however been a labour of love, as the extreme interest attaching to the experiments has sustained me during many sultry hours spent at the laboratory bench.

On the spur of the moment I could not answer all the questions brought forward by members at the last meeting, but will now attempt to the best of my ability to reply to each point in turn, and give them the fruits of some further investigations into the subject.

I am much indebted to the Chairman and to Mr. Pringle for their kind appreciation of my work, which I do not intend to stop at the point now reached, but hope to extend to the investigation of as many coals of different qualities as possible, besides extending the scope of the work on the samples already in my possession. Mr. Simpson has already offered to assist me in obtaining representative samples, and with his collaboration I hope, if time permits, to extend these researches over a wider area.

With regard to Mr Pringle's contention that "It seems impossible that a correct calorific value can be ascertained without first having analysed the coal for the constituent parts of its volatile matter," I am of opinion that the only absolutely certain way of testing a coal's calorific power is to burn it in a calorimeter, provided that the calorimeter can be depended on. The Bomb calorimeter when used with every precaution is certainly the most reliable, but Fischer's I have found to give quite dependable results if carefully worked.

I have now adapted electrical firing to the Fischer calorimeter, which is a distinct improvement, there being no loss of gas pressure such as occurs when igniting the coal with a burning splinter.

Mr. Pringle further remarks: "I do not suppose that the author maintains that the application of a formula to proximate analyses can determine the calorific value with the same degree of accuracy that would result where an ultimate analysis has revealed the component parts of the volatile hydrocarbons." This is quite true; at the same time an ultimate analysis to be of value must be conducted with extreme care. Not only should the carbon, hydrogen, oxygen and sulphur be accurately determined but nitrogen (a troublesome determination at any time) should be estimated. The ash should also be examined, as when this is at all excessive, which is the case with most Indian coals, it may exert a very appreciable effect on the calorific power.

Seyler in a paper on the "Chemical Classification of Coal"[1] for which I am indebted to Mr. Pringle, points out on page 493: "Certain errors are inherent in the method of ultimate analysis. The ash does not quite correctly represent the inorganic matter of the coal, owing to changes during the calcination, especially if pyrites are present, but I have not thought it advisable to attempt a correction. Possibly a more serious error is due to the presence of combined water in the inorganic matter of the coal, which will not only affect the oxygen but increase the hydrogen."

In addition to this if the ash contains a fairly high percentage of lime it was probably in the form of carbonate, which on combustion will come off as CO_2, and add to the carbon value of the coal while in reality it has no calorific value at all.

The different forms in which the sulphur may be combined is another possible source of error.

Seyler recommends that to minimise these errors a sample chosen for analysis should be as free as possible

1 Proceedings of South Wales Institute of Engineers, July 1900, pages 483-526.

from ash. When studying Indian coals these arguments take additional force by the higher percentage of ash with which we have to contend.

It is clear therefore that with any analysis however complete, sources of unsuspected error may exist, and for absolute certainty we must appeal to the decision of the calorimeter.

For the above reasons the value of ultimate analyses is largely discounted when an accurate calorimetric test can be made.

Mr. Thomson truly states that the percentage of oxygen differs very widely in different coals. This applies more particularly to coals which have a high percentage of moisture and volatile matter.

Seyler on page 490 of the paper already referred to states: "In accord with the views of Regnault and Grüner we get with increasing oxygen a regularly decreasing carbon contents, and on the whole an increasing amount of volatile matter." Further on he states: "Regnault's thesis that coals of similar nature are found between narrow limits of chemical composition is confirmed." Seyler in the same paper also points out that "two coals may have the same amount of volatile matter and yet differ enormously in composition, character, and calorific power." He then makes a comparison between two coals both with volatile matter about 35 per cent.

	C	H	O+N
Vivian & Sons Morfa 4 feet	88·27	5·66	6·07
Machen Rock Vein	75·98	5·15	18·87

and remarks these coals are at opposite poles in composition and calorific power and their yield of volatile matter is identical.

At first sight this would seem to discredit the Goutal formula and to render any attempt to correlate calorific values with proximate analyses nugatory.

On further examination, however, we see that the difference between the carbon contents of the two coals would be bound to show itself clearly in the determination of fixed carbon, and that consequently the ratios between their volatile matter and total combustible matter in these two examples would be very different when worked out according to the formula. It is a pity he did not give us proximate analyses of these two coals as well as the carbon, hydrogen and oxygen contents, as had he done so, the difference in character, composition and calorific value would have been clearly manifest. Goutal worked out his formula originally for true coking coals low in oxygen, which Cox modified and extended to coals high in moisture and volatile matter and consequently high in oxygen also, such as those occurring in the Philippines.

It may be taken as fairly proved that the volatile combustible matter contained in coal from seams of the same character has a pretty constant calorific value which can be estimated by direct experiment. That value has been proved to depend on the ratio of the volatile to the total combustible matter in the coal.

To prove this for the coals of a district such as Jharia or Raneegunge, we must have a series of analyses and calorific tests made, and the value of the factor "a" in the formula could then be deduced from direct experiment, and modified if necessary. The author's experiments have proved this up to a certain point, but much more experimenting is necessary, and to make the work scientifically valuable, ultimate analyses should also be made by which discrepancies between calculated and actual results might be accounted for.

When comparing calculated with calorimeter results in Table IV, we see that the value of "a" is evidently pretty correct for coals of the Raneegunge field.

Turning to Jharia coals, while some of the values approximate very closely, others show a marked discrepancy. A still greater number of samples from this field should be tested, and as a result it might be found necessary to modify the value of "a" as deduced from $\frac{100\ V}{V+C}$ for coals in this series. Personally I am inclined to think the value rather too high. This may be partly due to volatile constituents of the ash which have no calorific value, and would of course show itself still more in coals high in ash, making their theoretical calories higher than their actual calories. As the ash is of much the same nature throughout most seams, a correction might easily be worked out according to its quantity as determined by analysis, and this correction would be used in conjunction with the formula.

Much useful labour might be expended in these researches, and the author hopes that other members will collaborate with him in carrying on the work.

Coal washing seems to be little practised in India, but the comparison of results as suggested by Mr. Pringle might be interesting as showing whether the formula works out more correctly for the washed than the unwashed coal. Another method of comparing the formula would be to obtain different samples from the same seam, some containing clean picked coal and others with a percentage of shaly or other impurities found in the seam which would give a high percentage of ash.

If we found with the high ash samples that the calories calculated from the formula gave a high result compared with calorimeter values, while the calculated calories of the low ash samples approximated more closely thereto, we should be in a position to state that there is some ingredient in the ash which vitiates the accuracy of the formula and would make a correction accordingly.

The difference between moisture determined by the method laid down in the paper and that of drying in vacuo over sulphuric acid has been studied, and results of comparative experiments are published in the "Report of Committee on Coal Analysis."[1] The conclusions come to by the Committee were as follows :—

> "While it is evident that more water, and doubtless more nearly the amount of water actually present, can be obtained by drying for 24 hours in vacuo over sulphuric acid than by drying for one hour at 104° to 107°, the Committee are not prepared to recommend so radical a departure from common usage for general adoption. They believe that drying in vacuo should be used where great accuracy is desired, and in all cases where the determination is to be combined with an ultimate analysis, but that so long as the conditions of sampling are not more carefully controlled than at present the difference between the two methods (average 0·37%) is not great enough to justify the general adoption of the new method."

One other practical point brought forward by the Committee is however worthy of notice, which is that with coals high in moisture more moisture is usually found in the coarsely powdered than in the finely powdered coal. This shows that in finely powdering some dessication often

[1] Journal of Am. Chem. Socy., Dec. 1899, p. 1120.

takes place. For this reason a coal prepared for analysis should be quickly powdered and bottled at once.

Mr. Simpson considers that the actual ash contents of Bengal coals is from 20 to 50 %, and in some cases 100 % higher than the figures given in the author's analyses. On pages 101-102 I have clearly stated that I do not pretend that the samples analysed are absolutely representative of the seams from which they were taken. No. 61 on the list (Table IV) was however a sample taken from coal delivered during the running of a contract, and may be considered a true average of what the colliery (Central Kurkhand Coal Company) produces. At the same time I am of opinion that with careful picking the ash contents of coal loaded into trucks could be much reduced, and would then approximate more nearly to the figures given in the tables than is often the case at present. It is this custom of loading anything and everything which is black into the wagons which has discredited and ruined the Indian Coal Industry. There are few seams from which a certain amount of good coal cannot be won.

If, however, the proportion of shale and other impurities is so great that the picking of the good coal becomes a non-paying proposition, the seam must be abandoned.

This is another strong reason in favour of the sale of coal on the basis of its ash contents. It would then always pay to pick the coal carefully, and the higher price received would more than compensate for the extra expense incurred.

I am glad to hear that contracts have already been entered into on the basis of ash contents and fixed carbon. As a matter of fact these two items are quite sufficient for the practical valuation of a steam coal. As however such contracts cannot work successfully without the greatest care being taken that representative samples are sent for analysis, I hope to read a paper shortly before the Institute in which a general scheme for taking such samples is laid down. Where penalties are inflicted, a system of bonus should also be in force by which coal of a higher quality would be paid for at a higher rate.

Mr. Simpson's remarks about the higher price fetched for Dishergarh coal in the market may be explained by the fact that this seam, as well as the Shibpur, Poniata and Baraboni seams are very homogeneous in their character, that the coal from them can be relied on to give certain results, whereas the Jharia seams vary considerably in quality and ash contents, and the consumer is never quite sure what he is getting. The free burning quality also suits many consumers, especially as I am given to understand by an engineer friend, the art of stoking is not too well understood by the average Indian firemen, who can keep up steam easier with a free burning coal than with one which requires more scientific stoking, and more attention in order to get the best results from it. Freight is also an important item in fixing prices.

Referring to my statement with regard to the variation in quality of Jharia seams, this point is brought out in the table of analyses where we see great differences in the ash contents of different samples from the same seams. One particularly remarkable case with No. 15 seam would lead one to suspect that what is called 15 seam at Boraree cannot be 15 seam at Simla Bahal owing to the great difference in the ratios of their volatile to total combustible matter, indicating considerable difference in the chemical constitution of the pure coal. It is of course quite possible that the seam has changed its character owing to local influence. 16 seam also appears to differ in quality in different places, which may however be due to the way in which the individual samples were taken.

I should, strictly speaking, have said Bengal and not Indian coals in the para. in which it is stated, that "a pretty accurate idea of the position of an Indian coal in the Geological series can be arrived at from its proximate analysis." I have not as yet had time to study any but Bengal coals, though I should much like to extend these researches to coals of other districts. In the annexed table, however, will also be found analyses of two samples from the Pench Valley and one from Burma.

Likewise the statement regarding the lack of published analyses of Indian coals should be limited to Bengal.

I will, however, take an early opportunity of studying the analyses made by Mr. Simpson, and would suggest that the formula might be applied to them, and verified for these classes of coals.

Mr. Pringle has suggested that in a supplementary edition of my paper, the classification of coals under certain well defined qualifications be fully investigated. I agree with him that it is quite time such an investigation should be made, and the author puts forward the following suggestions tentatively for consideration of the members of the Institute:—

Classification of Bengal Coals.

It appears to the author that any classification requiring an accurate ultimate analysis of the coal is unsuitable for India, being too complicated.

Seyler advocates this for English, Welsh and some Continental coals and has divided them up into different classes depending on the percentage of carbon, hydrogen and volatile matter. Where ultimate analyses are easily available for all seams, and many investigators have published the results of their work as is the case in Europe, the correlation of these results and deductions therefrom become a matter of comparative ease and certainty.

Here in India we work under different conditions, and classification should be made on as simple a basis as possible. I would consequently suggest that the classification of Indian coals be made on the properties established, as the results of proximate analyses and practical coking tests.

Seyler applies the words hydrous, sub-hydrous, etc., to the hydrogen percentage in a coal. I would prefer to give the word hydrous its usually accepted meaning, and apply it to the moisture contents of the coal as freshly won (not after exposure for any length of time to atmospheric influences).

We have seen that with Bengal coals the moisture content runs fairly evenly through the seam in the unweathered portion of the coal, and it might well be used as one basis of classification in combination with other properties. Ash must of course be eliminated in any basis of classification as its quantity is quite independent of the class of coal being considered. In any classification we must take into account constant factors only.

The soundest basis of classification would be on the percentage of fixed carbon, and volatile combustible matter in the pure coal, ash and moisture free.

The percentage of volatile to total combustible matter for every coal analyzed by the author is given in Table IV under the heading $\frac{100\ V}{V + C}$. The difference between these numbers and 100 gives us percentage of fixed carbon in the pure coal.

Another basis of classification lies in the coking qualities of the coal. This it will be found may be largely deduced from the above percentages. The Bengal coals might then be divided into four or five general classes, all of which shade off more or less gradually one into the other.

1. *An-hydrous, semi-anthracitic* (*non-coking*).—Moisture generally below 1 %. Ratio of volatile to total combustible matter 20 % or less. Non-coking or slightly coking.

This class is represented by some of the lower Barakar seams such as Heilgers' anthracite from Salanpur. It would be interesting to find if this class of coal is at all widely represented in the field. Some Jharia coals have a very low percentage of volatile, but the author believes they are all coking coals so really belong to the next class. He would like further information on this point.

2. *Sub-hydrous, low volatile, bituminous or semi-bituminous true coking coals.*—Moisture usually from 1 to 2 %, sometimes below 1 %. Ratio of volatile combustitle to total combustible from 20 % to 30 %. The varieties having less than 25 % volatile might be classed as semi-bituminous and those above as bituminous.

They all yield a good hard coke suitable for foundry and metallurgical purpose and are good steam coals. Some Barakar seams and some of the Jharia seams such as 10, 12, 13 and 15 might be classed as semi-bituminous; Giridih and the higher seams in the Jharia series as bituminous. They gradually merge into the next class.

3. *Hydrous, high volatile, bituminous, long flame, coking coals.*—Moisture from 2 to 5 %. Ratio of volatile to total combustible matter 30 % to 40 %. They are coking coals but the coke is usually light and porous and

not so suitable for metallurgical and foundry purposes as the coals of No. 2 class. They are good gas and steam coals.

They are represented by a few seams in the Jharia district, such as Murlidih and Bhatdee and No. 18 seam which lies on the border line and by the lower seams in the Raneegunge field, such as Dishergarh, Shibpore, Jyramdanga, etc.

4. *Per-hydrous, sub-bituminous, long flame, non-coking coals.*—Moisture over 5 %. Ratio of volatile to total combustible matter over 37 %. Non-coking or only slightly so.

This class is represented by some of the upper seams in the Raneegunge field and in the Pench valley, C.P. There is a large number of coals which lie on the border land between classes 3 and 4, and their classification might depend principally on their coking properties. This class is much in the nature of a splint coal and should make an excellent household or steam coal where free burning qualities are required.

5. *Lignites.*—These are hardly represented in the Bengal field, but exist in other parts of India and consist of coal with high moisture generally over 10 %, high volatile ratio over 40 %, and are all non-coking.

Mr. LaTouche doubts whether the geological position of a seam can in any way be inferred from analysis of the coal, and gives us a reason that such inferences would be largely discounted by the effect of atmospheric influences, in cases where the sample of the seam is taken from near the surface.

It is a particularly noticeable fact that the character of the combustible portion of a coal remains remarkably constant throughout a seam. A seam containing high volatile bituminous coal at the surface will not produce low volatile or anthracitic coal in depth.

In the list in Table IV analyses are given of samples of the Dishergarh seam taken from near the surface[1] to a depth of 1,940 feet from a bore hole. The coal distinctly belongs to the high volatile bituminous class all through; it does appear to gain in calorific power somewhat in depth, but the distinguishing characteristics of the seam remain the same from the outcrop to the greatest depth.

Certain lower seams in the Barakar field are likewise semi-bituminous or semi-anthracitic from the surface downwards, and cannot be classed differently. This particular class of coal is not found in the Upper Raneegunge measures; its analysis therefore indicates clearly the horizon from which it comes.

I do not wish to assume for a moment that this applies to all other districts and measures in India. Other conditions may have existed in other places, but its significance as far as the Bengal measures are concerned is very apparent.

I certainly think the map of the coal-fields should have an index, and the class of coal with average proximate analyses of all the principal seams might be appended thereto with advantage.

Table IV has been somewhat enlarged since the paper was read first, some bulk samples of coal as received at the Mint being included, also samples of Pench Valley coal kindly sent by Messrs. Shaw, Wallace & Co., and a weathered sample of coal from Burma sent by Mr. H. A. Pringle.

Table VI has also been newly added as the result of

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1 All unweathered samples.

experiments carried out by the author since the original publication of the paper. Its particular interest is that it shows the chemical composition of the pure coal substance of the different seams with calorific value of same.

Mica in Nellore.

BY

A. Krishnaiya, B.A., Nellore.

(With Plates 9-16.)

Mica occurs in the District of Nellore, Madras Presidency, as one of the constituents of pegmatite which is intrusive into mica-hornblende schists. Associated with gneiss it extends in N.N.W.-S.S.E. direction from beyond Gudur to Gudavallur. This region may be divided into the four mining zones of (1) Gudur, (2) Rapur, (3) Atmakur, and (4) Kavali; of these Rapur is the most valuable.

Description of Pegmatite.

The pegmatite is a coarse holocrystalline aggregate of quartz and felspar, the latter being commonly microcline. Its secondary minerals are garnet, hornblende, apatite, beryl and tourmaline. (*N.B.*—Readers who wish to pursue further the geological aspect are referred to Sir Thomas Holland's monograph on the subject, Memoirs, Geological Survey of India, Vol. XXXIV.)

Distribution.

The mines are located in the Government unoccupied lands and Forests, patta,[1] shrotriyam,[2] and zamindary[3] (venkatagiri) lands, the more productive ones being mostly in Government lands. The most important villages associated with mining within the knowledge of the writer are—

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[1] Patta land—state land granted in free-hold to a tenant.

[2] Shrotriyam land—private land enjoyed as a gift from the Government.

[3] Zamindary—a permanently settled estate granted to a proprietor under an agreement by the Government.

1. *Gudur Zone.*
   (*a*) Mangalpur.
   (*b*) Vodur.
   (*c*) Patragunta.
   (*d*) Budanam.
   (*e*) Chennur.

2. *Rapur Zone.*
   (*a*) Saiyidapuram.
   (*b*) Chaganam.
   (*c*) Nandalagunta.
   (*d*) Anantamadugu.
   (*e*) Vorupalli.
   (*f*) Inikurti.
   (*g*) Kalichedu.
   (*h*) Marupur.
   (*i*) Biradavolu.
   (*j*) Turimerla.
   (*k*) Untukur.
   (*l*) Tummalatalupur.
   (*m*) Griddalur.
   (*n*) Mudigodu.

3. *Atmakur Zone.*
   (*a*) Prabhagiripatnam.
   (*b*) Ammavaripalem.
   (*c*) Tatiparti.
   (*d*) Bathulapalli.
   (*e*) Srikolanu.

4. *Kavali Zone.*
   (*a*) Dundigam.
   (*b*) Uppalur.
   (*c*) Gudavallur.

The richest deposits in which work is being actually carried on or only temporarily suspended are :—

1. Mr. A. Subba Naidu's ..	1. Tellabodu.
	2. Kalichedu.
	3. "D" mine.
	4. "F" mine.
	5. Nandalagunta.
	6. Palamani.
2. ,, R. Laksminarasa Reddy's	1. Laksminarayana
	2. Reppala Dibba.
3. Messrs. Haji Md. Badsha Shahib & Co's. ..	1. Pallimitta.
	2. Shah.
	3. Nandalagunta.
4. R. V. Kuppuswami Aiyar's ..	1. Sankara.
	2. Seetharama.
	3. Rocklands.
5. Mr. P. Venkatrama Naidu's..	1. Venkateswara.
	2. Mahalakshmi.
6. ,, K. Penchalu Reddy's ..	1. Varadaraja.
7. ,, Y. G. Venkatasubbiah Chetty's ..	1. Bhupati.

The first and third may be regarded as the pioneers of mica mining in the District.

Description of the Mines.

The "Shah" and "Tellabodu" deposits are located on either end of what appears to be a broad syncline ; the latter deposit is infinitely the richer. It is a hillock three miles west of Saiyidapuram village. As the suffix of the name *Tellabodu* indicates, it is a huge spindle-shaped deposit, which, except at the top where the pegmatite outcrops, is covered by hornblende and mica schists. The outcrop is about four furlongs in circumference. Ramifications of the deposits are observed to the south and west of it. Opencut working has been carried on to a depth of about seventy feet from the surface, and thereafter levels have been driven. Two floors have been formed, and they are connected by a shaft. The mica is greenish, with spots which depreciate its commercial value. The mine has been worked for over 10 years and has steadily maintained an average daily output of 1000 lbs. of trimmed mica. It may be interesting to learn that some "moosas" ("books of mica") occurred here in such dimensions that it took from 20 to 25 days to clear them. In its active days the mine yielded about 2500 lbs. or a daily gross income of Rs. 2000/-, and the labour employed was over 800 persons.

"*Kalichedu*" is also a big deposit in a shrotriem village of the same name. Abundant and big plate-mica is got here from a highly decomposed pegmatite; the cost of production is greatly minimised by the very limited consumption of explosives. 2500 lbs. of daily output is recorded. The variety is 'pale-ruby.'

"*D*" *Mine.*—This is a long lens over 250 feet by 150 feet, and lies about a mile and a half west of Inikurti village on the Podalakur-Rapur road. The pegmatite is on either side associated with chlorite, hornblende and mica schists. Quarrying was pursued to a depth of about 150 feet from the surface, and levels were thereafter driven. The maximum output recorded was over 2000 lbs. per diem, giving work for about 1000 coolies. Indiscriminate work affected the produce during recent years. The mica is silvery white. It secured one sovereign and more per lb. in the market and is the finest in the district.

"*Pallimitta*" at the northern end of Saiyidapuram village is also a big deposit, and yielded about 700 lbs. a day for some time. Both clear and stained varieties of mica are won. Opencut work extended to a depth of about 70 feet, and further operations were pursued by horizontal levels.

"*Lakshminaryana*" is another valuable mine situated N. E. of Chaganam village. It is in a big boss, the eastern portion of which is formed of huge blocks of clear quartz and felspar, which in places is greenish. Work was started on the eastern side and extended downwards to a depth of 70 feet by opencut; mining was carried for a further 60 feet. Some of the levels driven here yielded abundant mica. The western margin, however, which slopes gently inwards, is composed of small pieces of felspar and quartz. Mica does not seem abundant here, and is full of flaws which cause much wastage. Beautiful hexagonal imprints of large books of mica are observable on the quartz. The writer was informed that in its best days, the daily output approached 700 lbs. of trimmed mica, but the average yield is between 300 and 400 lbs.

"*Sankara.*"—This is three miles west of Griddalore village. It is a vein over 100 feet long and 40 feet across. Mica schist is observable about the centre of the vein. In 1907 and 1908, the daily yield is reported to have exceeded 600 lbs. Apart from mica, this mine is particularly interesting for producing samarskite, which was recently identified by Mr. R. R. Simpson, Inspector of Mines. It appeared at the surface as a very thin vein, a few inches thick, and runs down the pegmatite almost vertically; it is associated with mica. The vein is reported to grow richer at greater depths. The mineral appears to vary in habit.

"*Bhupati*" is another quarry about a mile N.E. of "Sankara." The pegmatite is thin and much decomposed. Abundant mica is won from the schist. Expense from explosives is almost nil. The variety is stained mica.

Leaving the Rapur Zone, Mangalpur mine is worthy of note in the Gudur Zone. The deposit is in the form of a vein 10 to 15 feet thick in chlorite-schist. The mica is clear and commands a good price.

"*Reppala Dibba*" is important in the Atmakur Zone. It is a long vein about 150 feet long and 40 feet thick. The associated schist is mostly hornblendic, and contains much iron. Large and fully developed crystals, 5 to 6 inches in diameter, of beryl were found here. Both clear and stained varieties of mica are got. In its active days, it yielded between three and four hundred lbs. a day. The Kavali quarries do not call for notice.

The following table gives the annual output of mica from the District during the last decade :—

TABLE I.

	lbs.
1898-99	260279·125
1899-00	937860·300
1900-01	1079516·250
1901-02	398187·625
1902-03	357614·125
1903-04	250995·563
1904-05	846467·250
1905-06	1884042·375
1906-07	1581983·438
1907-08	1265735·938

The above figures may be graphically represented as on facing page :—

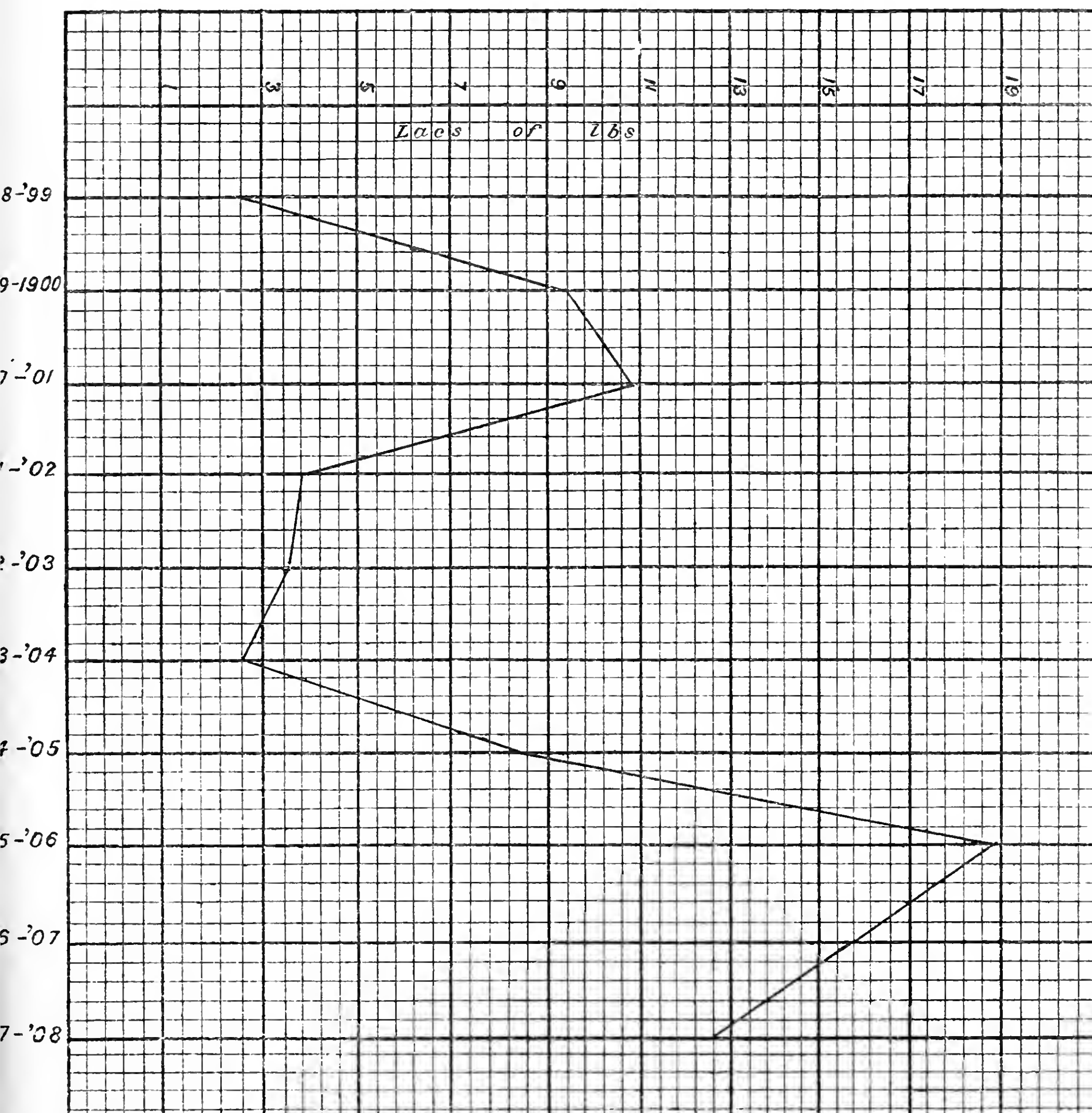

1
3
5
7
9
11
13
15
17
19
Lacs of lbs
8-'99
9-1900
-'01
-'02
-'03
3-'04
-'05
5-'06
6-'07
7-'08

TABLE II.

Name of Mine	1898 Cwt	1898 Rs.	1898 £ s. d.	1899 Cwt	1899 Rs.	1899 £ s. d.	1900 Cwt	1900 Rs.	1900 £ s. d.	1901 Cwt	1901 Rs.	1901 £ s. d.	1902 Cwt	1902 Rs.	1902 £ s. d.
1 Tellabodu	718 063	1,98 4.9	13,220- 5-4	1007 054	3,46,422	23,094-16-0	3025·714	4,26,220	28,414-13-4	2382 071	2,54 157	16,943-16-0	940 214	90,332	6 022- 2-8
2 Pallimitta	110·277	9,252	616-16-0	695 007	32,950	2,196-13-4	874 058	46,850	3,123-18-8	423 043	50,671	3,378- 1-4	634 016	82 664	5,510-18-8
3 'D' Mine ..	..	..	.	205 670	25,391	1,693- 5-4	148 830	6,101	406-14-8	404 578	07 907	1 531 2-8	109 402	20,409	1,360-12-0
4 Nandalagunta .	.	.		57 813	2,785	185-13-4	197 503	6 088	405-17-4			.	5·008	350	23- 6-8
5 Palamani		..	..	73 750	11,516	767-14-8	943 011	47,238	3,149- 4-0	66·232	6 02[illegible]	401-10-8	.		.
6 'F' Mine .		..	..	..	.	..	108 176	33,704	2 250-14-8	338 134	37,028	2,468-10-8	110 107	31,728	2,115- 4-0
7 Lakshminarayana	.	..	..		..		..			44·134	62,142	4 142-16-0	881	92,723	6,181-10-8
8 Reppaladibba ..	..	..	..	..		..	73·768	6,949	463- 5-4	150	17,077	1,138- 9-4	..		..
9 Kalichedu ..	.	..	..	..		..	.				..		.	.	.
10 Orupalle .		..	..	..	.	.		..	..				.		
11 Sankara		..	..		..	..		.			..	..	..	..	
12 Mahalakshmi ..		..	..	..	..	.		..					..	.	
13 Venkateswara ..	..	..	..			..								..	
14 Anantamaungu .		..	..	.	..	..					.	.			.
15 Bhupati	.	..	..		..	.					.	.			
16 Zogipalle	..	..	..	.	..	.							.	..	

Name of Mine	1903 Cwt	1903 Rs.	1903 £ s. d.	1904 Cwt	1904 Rs.	1904 £ s. d.	1905 Cwt	1905 Rs.	1905 £ s. d.	1906 Cwt	1906 Rs.	1906 £ s. d.	1907 Cwt	1907 Rs.	1907 £ s. d.	1908 Cwt	1908 Rs.	1908 £ s. d.
1 Tellabodu	181 000	18,800	1,253- 6-8	1224 000	1,41,912	19,460-16-0	3961 000	3,96,561	26,437- 8-0	10474	2,68,203	17,880- 4-0	4777	[illegible]	[illegible]	2095 125	[illegible]	[illegible]
2 Pallimitta	154	19,593	1,306- 4-0	401	31 947	2,129-16-0	278 000	23,874	1,591-12-0	1136	50,791	3,386- 1-4	478	34 975	2 198 16-8	368 821	[illegible]	[illegible]
3 'D' Mine				20	2,700	180- 8-0	34 030	1 465	97-13-4	76·000	6 426	428- 8-0	74	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4 Nandalagunta	1 000	34	2- 5-6	37	3,638	242-10-8	2	75	5- 0-0	287 000	22 467	1,531 2-8	253	10 208	680-16-0	247 [illegible]	[illegible]	[illegible]
5 Palamani	.			22	821	54-14-8	194	15,579	1,038-12-0	1126	46,642	3,109- 9-4	504	16 010	1,067- [illegible]	270 207	[illegible]	[illegible]
6 'F' Mine	104 804	29 287	1,952- 9-4	115	17,830	1 180- 1 4	52	3,070	204-13-4	163	31,048	2,069-17-4	200	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7 Lakshminarayana	676	1 17,104	7,806-18-8	1092	1,10 078	7,338-10-8	934	1 26 332	8 422- 2-8	830	1,04 131	6,942 1-4	959	57 225	815- 4-0	[illegible]	[illegible]	[illegible]
8 Reppaladibba	.	..					65	5,021	334-14-8	20	14 823	988- 4-0	67	7 1[illegible]	475-13-4	92 446	5,71[illegible]	[illegible]
9 Kalichedu	757	64 922	4,328- 2-8	169	15,000	1,000- 0-0	494	55 314	3 687-12-0	4406	60,000	4 000- 0-0	2146	42,324	[illegible] 5-4	[illegible]	1,21,2[illegible]	[illegible]
10 Orupalle	8	1,000	66-13-4	46	4,000	266-13-4	50	5,638	375-17-4	878	15,000	1,000- 0-0	375	25,[illegible]	1 686-[illegible]	105 [illegible]	[illegible]	[illegible]
11 Sankara							194	15 132	1,008-16-0	384	28,261	1 884 1-4	341	30 708	2 047- 4-0	[illegible] 277	[illegible]	[illegible]
12 Mahalakshmi	.			16	1,515	101- 0-0	123	16 240	1,082-13-4	12	1,371	91- 8-0	..			124 411	10,59[illegible]	[illegible]
13 Venkateswara						..	40	5,033	335-10-8	5 045	502	33- 9-4		.		[illegible]	1 22[illegible]	[illegible]
14 Anantamaungu													221	[illegible]	258-16-0	[illegible] 540	11 02[illegible]	[illegible]
15 Bhupati													101	13 466	897-14-8	[illegible]	[illegible]	[illegible]
16 Zogipalle							72	8,000	537- 6-8	445	6,000	400- 0-0	11	1 124	74 18-4			

A. Krishnaiya
5-7-10

TABLE III.

MICA EXPORTS OF MADRAS FROM 1905.

	1905 Cwt	1905 Rs.	1905 £ s. d.	1906 Cwt	1906 Rs.	1906 £ s. d.	1907 Cwt	1907 Rs.	1907 £ s. d.	1908 Cwt	1908 Rs.	1908 £ s. d.	1909 (First half year) Cwt.	1909 Rs.	1909 £ s. d.
1 Henrich A. Brandt	5914 440	1,96 324	13,088- 5-4	10455 571	4 11,065	27,404- 6-8	7204 062	3,63,104	24 208- 0-0	3667·410	2 17,715	14 514 10-8	1168·526	77 652	5,176-16-0
2 Anglo-Indian Trading Co	1706 167	1 98,028	13 201-17 4	17 028	3 800	253- 6-8	1161·007	1,33,400	8,893- 6-8	2445·080	1,32,920	8,861-14-8	74 167	8 300	553 6-8
3 Ramaswamy Naidu & Sons	24 758	2,245	149-13-4				.	.	..	.	.				..
4 H. M. Badsha Saheb & Co.	944 330	88,751	5,916-14-8	3040 348	2,55,847	17,056- 9-4	1345·241	73,246	4 883- 1 4	642 214	46,203	3,080- 4-0	250 991	17,664	1,178-13-4
5 C. Raghavalu Naidu	593·133	66,562	4 437- 9-4					.	..						.
6 Binny & Co	172 071	21 166	1,411-1-4	134 464	16,918	1 127-17-4	66·545	4,867	324- 9-4	105·223	4 146	288- 2-8	34 071	2 344	156- 5-4
7 Oakes & Co	1 452	600	40- 0-0				.						..		
8 Chambers & Co	45·535	5,100	340- 0-0				53 004	9,300	620- 0-0	53 035	596	39-14-8			
9 C. Venkatarangam Naidu	967 857	1 08 401	7,226-14-8	2434 303	2,72,053	[illegible]- 4-0	648·000	72,077	4 845- 2-8	1011 571	1,11,290	7,353- 1-4	736 071	82 900	5 530-13-4
10 Indian Granite & Co	17 857	2 000	133- 6-8				.	..		.	.	..	.		.
11 P. Somoo Chetty				42 806	3,210	214- 8-0	89 580	9,283	618-17-4	7 142	200	13- 6-8			
12 C. Venkataramaungam Naidu				66 044	7,300	49[illegible] 5-4			..			..	.		
13 C. Venkataswamy Naidu				20 883	3,011	200-14-8		..							
14 M. Raghavalu Naidu				1 0	112	7- 9 4		.				..	.		
15 Parry & Co.				10·089	1 421	94-14-8		..	..	.	.	.	..		
16 K. C. Kumaraswamy Moodelliar				[illegible] 258	2 605	173-13-4		..				.			
17 Alfred Young & Co				51 964	3,383	225-10-8							..		
18 Gordon Woodroffe & Co				14 302	3,496	233- 1-4				..		.	..	.	
19 K. E. Heyuemens				17 839	977	65- 2-8	.						.		
20 C. L. C. Cantham & Co				20 785	750	15- 0-0	.			.		..			
21 P. Krishnaswamy Moodelliar				17 857	500	33- 6-8		.		.		..	..		
22 Ramsay & Co				28 732	4,087	272- 9-4	143 091	15,664	1,044- 5-4	61·090	6,213	414- 4-0	.		
23 T. Govindarajulu Naidu				31 25	3,625	241-13-4	20·0	6,720	448- 0-0		.	..	..		
24 S. Venkatarangam Naidu				118 151	13,233	882- 4-0				.		.	.		
25 K. Ramanathan Chetty				92 857	11,000	733- 6-8	20 465	2,475	165- 0-0	..					
26 C. Venkatakrishnama Chetty						.	101·5	25,345	1,689-13-4				..		
27 R. Vakulabhanja & Sons					..	..	8·929	1,000	66-13 4				.		
28 R. Dallaram				..	.		1·0	16	1- 1-4			.	..		
29 C. Veerasamy					.		..	..	..	38·0	4,256	283-14-8	..		
30 Walker & Co.							.	.	.	26 392	1,434	95-12-0	20·080	3,370	224 [illegible]
31 Parsons & Co					.		.			27·544	1,875	125- 0-0	.	..	
32 Madras Mica Export & Co.							.		.	306 185	15,025	1,001-13-4	177 080	5,625	375- 0-0
33 C. Singaram Modali													16·892	1,802	120- 2-8

Table II gives the production from important individual mines during the last decade. The value does not represent the actual realisations, but value fixed by the Government according to a prescribed scale.

Note.—Figures for production were obtained from office records, with the kind permission of the District Forest Officer, Nellore.

Table III shows the total production of the District during the past five years, with the names of the buyers. Table IV gives the ports to which the mica was shipped.

TABLE IV.

MICA EXPORTS OF MADRAS, DISTRIBUTED ACCORDING TO PORTS FROM 1905.

YEAR 1905.

	Port.	Weight in Cwt.	Value in Rs.	Value in £ s. d.
		Cwt.	Rs.	£ s. d.
1	London	5337·348	6,32,785	42,185-13-4
2	Hamburg	1175·75	43,886	2,925-14-8
3	New York	114·75	9,051	603- 8-0
4	Calcutta	17·857	2,000	133- 6-8
5	Hamilton	9·143	815	54- 6-8
6	Trieste	1·483	600	40- 0-0
7	Antwerp	0·196	20	1- 6-8
8	Canada	0·196	20	1- 6-8

YEAR 1906.

		Cwt.	Rs.	£ s. d.
1	London	7753·357	6,83,971	45,598-12-4
2	Hamburg	9447·812	3,10,063	20,670-17-4
3	New York	2053·517	23,311	1,554- 1-4
4	Marseilles	138·901	5,104	340- 5-4
5	Hamilton	15·160	1,137	75-16-0
6	Rangoon	1·0	112	7- 9-4
7	Calcutta	0·133	25	1-13-4

YEAR 1907.

		Cwt.	Rs.	£ s. d.
1	London	7169·187	6,00,153	40,010- 4-0
2	Hamburg	3598·821	1,11,153	7,410- 4-0
3	Marseilles	83·038	9,300	620-0-0
4	New York	19·812	2,977	198- 9-4
5	Hamilton	19·017	1,801	120- 1-4
6	Birmingham	1·919	291	19- 8-0
7	Calcutta	1·0	16	1- 1-4

YEAR 1908.

		Cwt.	Rs.	£ s. d.
1	London	6838·607	4,82,349	32,156-12-0
2	Hamburg	1495·178	48,063	3,204- 4-0
3	Rotterdam	371·857	15,400	1,026-13-4
4	Hamilton	86·696	664	44- 5-4
5	New York	5·455	502	33- 9-4

1909 (1ST HALF YEAR).

		Cwt.	Rs.	£ s. d.
1	London	193·633	1,80,861	12,057- 8-0
2	Hamburg	371·982	13,089	872-12-0
3	Rotterdam	177·866	5,625	375- 0-0
4	New York	1·633	232	15- 9-4

Varieties.

The varieties from the district are (1) clear, (2) pale-green ,(3) green, (4) pale-ruby, (5) stained. Relatively the first four are less produced and are decidedly more valuable. Pale-ruby is rare and is found at "Kalichedu" and "Pattabhirama" quarries. The green coloration is due to traces of chromium. The spots observed in plate-mica are adventitious inclusions, chiefly oxides of iron. Spots besides disfiguring mica and depreciating its value thereby cause much disadvantage in resisting the attempt to maintain the marketable standard of thickness of plate-mica, by terminal splitting. Mica in pegmatites associated with chlorite schist appears to be free from these ferruginous inclusions. When altogether free from them, it is white or pale-green. A peculiar structure common to all the above varieties of mica is called "lining", which throws it into gentle ridges. This structure is probably superinduced by unequal pressure during crystallisation. "D" mine is reputed to yield the finest mica.

History of Mining.

As far back as 1887 or a little earlier, certain ramblers found books of mica in the Rapur Zone. Their curiosity being excited, they took the stuff to Madras to learn if it would be marketable. News regarding its utility and demand in Europe and America turned wealthy landholders into speculators. The

"Yenadis," a wild tribe, who owing to their habit of searching for mice in the jungles, has acquired skill in burrowing, were employed for exploring. Observation and experience gained from time to time familiarised them with the associated rocks, and trial pits which are generally two feet across and a yard or two deep, were sunk around exposed quartz associated with schist. General success attracted more capital, and certain respectable Indian and English firms entered the field. Increased competition led to extension of the mining into other parts of the District. Gradually, the number of mining concessions granted considerably increased, and still continues to do so. At present there are about 120 leases granted by Government. These do not include mines in private properties. The working was supervised at first by Forest Rangers, but on account of increasing work, whole-time Mica Inspectors were later on appointed.

Cost of Production.

This depends on the output, supply of labour, consumption of explosives, drainage, waste in trimming, and expense of transport to Railway stations. Labour is fairly cheap and available in plenty in the District. The daily wages of a man are three annas (threepence in English money), of a woman two annas, and of a boy or a girl from one anna to two annas, according to age. Those who work in a mine at night are paid from ten to fourteen annas. Generally there is no difference maintained in rates between those who work in the quarry and those outside it. Expert coolies are paid about five annas each. Mica cutters receive from four to five and a half annas. Each man cuts about 70 lbs. a day and can classify about 100 lbs. Men are employed for drilling and similar hard work, while women carry the excavated material to the dumps. Children prepare mica rounds out of which films are made. The explosives generally used are gunpowder and dynamite. Where much decomposition of the pegmatite has taken place, as at "Kalichedu" and "Bhupathi," the charges under this head are reduced to a minimum. In damp ground gunpowder is discarded for dynamite. Drainage is effected generally by the force-pump. "Pallimitta," "Kalicheddu," "Sankara," "D," "F," and "Laksminaryana" mines have oil engines. Where single suction is not possible, water is transported from one sump to another till it reaches the surface. The fuel generally used for feeding engines is wood, which is cheaply got by concessions obtained from the Forest Department. Coal is also used, but transport is costly. Suitable arrangements are not made even in large mines to keep out surface-drainage, so that in the rainy season, increased subterranean inflows of water and surface rain-water impede active work. Where there are no pumping-engines work is generally suspended during the monsoons.

Mica-cutting.

Wastage in trimming mica is peculiar to each mine. Twenty-five per cent. of the mica removed from some mines represents saleable mica, while in others only ten per cent. of the gross output is valuable. A portion of what is thrown off as unfit for plate-mica is cut into rounds for films. The method of cutting practised here seems to be different from that prevailing in Bengal. There are two methods employed here. One of them is called "rule cut", *i.e.*, cutting in accordance with sizes previously ruled off by a knife. This method is resorted to in cutting clear mica. The second method is "chuttu kathrinpu", *i.e.*, cutting away following the course of flaws. The Bengal method differs from this in that the latter while following the direction of flaws gives a rectangular shape to the slab of mica. This shape is probably due to rules in force. The first method involves more wastage but secures greater price, while the latter minimizing the wastage lowers the demand. It seems rather hard to determine which is the more profitable course to adopt, but the best one appears to be that prevalent here, to wit, adopting the first method in the case of clear mica, and second in respect of spotted mica.

Transport includes haulage at the mines, and removal of mica to the Railway stations. Unfortunately machine power is rarely employed for haulage. Men and women are engaged for the work, and much waste of money and energy result. In a few mines tipping-tubs running on rails are used for conveying excavated material to waste-heaps. Such an arrangement exists at the "Nandalagunta" mine of Messrs. Haji Md. Badsha Saheb and Co., for removal of broken rock from inside the quarry. The cost of carting is rather high for want of convenient approaches to Railway stations. It generally works out at two annas per mile for a cart laden with ten cases of 100 lbs. each. The average cost of producing one lb. of marketable plate-mica exclusive of transport lies between four and five annas.

Royalty.

Among other expenses, those standing out prominently are royalty of five per cent. *ad valorem*, according to a fixed scale, and commissions paid to Madras and London brokers.

It is extracted from the mining rules.

Class.		Stained mica.				Clear mica.		
		Rs.	A.	P.		Rs.	A.	P.
I.	4 sq. inches and under ..	0	2	0	per 1 lb.	0	3	0
II.	Above 4 sq. in. and not more than 8	0	4	0	,,	0	6	0

Class.				Stained mica.				Clear mica.		
				Rs.	A.	P.		Rs.	A.	P.
III.	Above 8 sq. in.	and not more than	16	0	10	0	per. lb	2	0	0
IV.	,, 16 ,,	,,	32	1	8	0	,,	3	8	0
V.	,, 32 ,,	,,	48	3	0	0	,,	5	0	0
VI.	,, 48 ,,	,,	64	4	8	0	,,	7	0	0
VII.	,, 64 ,,	,,	80	6	0	0	,,	9	0	0
VIII.	,, 80 ,,	,,	96	7	8	0	,,	11	0	0
IX.	,, 96 ,,	,,	112	9	0	0	,,	13	0	0

And so on in proportion; the size of the plates being calculated according to the greatest rectangular area the slabs will yield. Falenisy mica (scrap mica) 8 annas irrespective of size and quality. Besides royalty, every plot of Government or patta land is charged with surface rent, and dead rent or royalty, whichever is greater. (The rate of acreage fixing the rents varies with the character of the land.) At first, Government claims were based on "acreage system," as is prevalent, I hear, in Bengal. In recent years, the present royalty system was introduced as an improvement on the old one beneficially both to the miner and Government. The royalty on sized-mica and films is the same. The average market value of the former stands at 1 rupee, while that of the latter at 6 annas per lb. The average profit accruing from successful mining appears to be about 50% of investment, and in spite of the totally speculative character of the industry and absence of metallurgical processes co-existent with ore-treatment, a small increase of royalty, by way of revision, on sized-mica may admit of consideration.

The miner's indifference to or helplessness in arranging contracts with mica buyers in Europe or America or indirectly appointing agents to sell his consignments, cuts off about 15 per cent. or more of sale-proceeds which he might otherwise secure for himself. Madras is the nearest sea-port, being within five hours run from Nellore by rail.

Situation of Mines.

Location of mines is generally in jungle, and approaches to the railway stations are not convenient. In some cases, however, proximity to metalled roads diminishes the inconvenience. Cartage, therefore, is generally more than what it would otherwise be. The railway stations of export are Kavali, Nellore, Manabone and Gudur.

Mining.

Scientific mining is rare. The miner simply follows the books of mica without making provisions for expansion of work, so that after pursuing operations for a time, he has to suspend them for want of accommodation. Stoping and clearing off overburden are not as satisfactory as might be desired. In consequence, downward currents of water wash the overburden into the quarry during the rains, and the miner is saddled with much deadwork. Driving horizontal levels is the only form of mining progress. Through want of foresight, the waste-dumps are thrown too near the quarry and sometimes long levels cannot be driven owing to fear of subsidence or to the uncertainty of making the concern profitable after carrying out the amount of deadwork involved in the removal of dumps. The underhand method of stoping is employed.

Scope for Improvement

The miners and their Managers at the mines are generally people who have not had any recognized scientific training for their work. They focus all resources and energy merely towards excavating mica. The desirability of employing a man of scientific attainments wherever feasible is evident, when we recollect the identification of wolframite in mica schist in the Central Provinces, and Samarskite in pegmatite at

"Sankara" mine in this district. The writer has recently discovered the occurrence of manganese-ore in the district, and as minerals of more or less importance, for which there is a demand in the market, may occur, ignorance of their identity and value leads to their being consigned to the waste heap For want of knowledge of mining and minerals, many a miner has suffered heavily. The small capitalist has been thrown into irretrievable ruin. The invariable practice of prospecting round almost every exposed piece of quartz, which in cases happen to be mere segregations in schist, has necessarily often resulted in failure. The services of a competent person having some technical attainments, the reduction of working expenses by employment of suitable machinery for haulage and drainage and the avoidance of brokerage appear to be determinative factors in promoting the industry and making it more paying. As it is, the circumstances are not only making the industry appear less profitable than it really ought to be, but, more than that, are largely discouraging its extension

Conclusion.

To conclude:—Mica mining has, on the whole, been successful in Nellore and has done much to relieve the distress that prevailed amongst the labouring classes during recent famines. The number of labourers working at the mines in active days may be computed to be about 4000 daily. Other places fit for mica mining are known to the writer to exist in the Districts of North Arcot, Kistna and Godavari. Experiments may, like those in Nellore, prove profitable or create opportunities for finding new minerals. With the present growing enthusiasm for developing industries in this country, this branch of the mining industry deserves a great deal more encouragement than has fallen to its share till now, and it is the belief of the writer that a greater amount of capital put into it would, with the assistance of modern scientific methods, make it not only profitable, but a distinctly important form of investment in this country.

Discussion.

H. A. Pringle said:—Mr. Krishnaiya's contribution to the literature of this Institute is of general interest to all of us but of peculiar interest to those of us who have been associated with the mining of the rarer metals in different parts of the world. I gather from the author's paper that a basis exists in Nellore for the establishment of a sound and remunerative industry—but that a very different system of work must first supersede the present methods, and that probably an amalgamation of interests—the grouping under one control of several mines—is desirable. I would like to ask Mr. Simpson—who I believe has a considerable knowledge of the Nellore district—if there is any defined leader or indicator, connecting one mica book with another—anything to show the miner in what direction he should next proceed for the purpose of locating another "book." Can he tell us if there is any noticeable increase in size or difference in shape in the "books" as depth is attained, or any alteration in the laminæ of the books. Also is there a distinct oxidised zone or "water level", and if so, do the individual books of mica alter in any way—is the mica purer in depth?

R. R. Simpson said:—I noticed that the Honorary Secretary in reading the paper fought shy of the names of the mines. The saying "What's in a name?" does not apply to Nellore mica mines. From the mine-owners' point of view the name of a mine has a most important bearing on the success of the venture. It is not at all uncommon to rechristen a mine in the hope of an improving yield of mica. Many of the mines are called after Hindoo deities who are presumed to exercise a benevolent influence over their fortunes. One rich mine rejoices in the name of "*Sitaramayanayyaswami*"; but it had unfortunately to be closed down recently as it had become unsafe.

As perhaps the only member present who is familiar with the Nellore mica mining area, I should like to express my appreciation of the interesting paper contributed by Mr. Krishnaiya. Such papers are extremely useful in supplementing the scientific descriptions of the Geological Survey.

The mica belt is well situated in regard to markets, for the East Coast Railway runs parallel to its margin and within 10 to 15 miles of the chief mines. There are metalled roads within a few miles of practically every mine. The country is flat and covered with a fairly light jungle with a thorny undergrowth. A covering of alluvium renders prospecting work somewhat difficult.

It is an unfortunate fact that the mining industry is a declining one. Since 1906 the output has decreased from 24,420 cwts. to 8,908 cwts. in 1909. This is entirely due to lack of enterprise. The majority of the known rich mines are far from exhaustion, but for successful exploitation now require capital and the application of modern mining methods. The writer of the paper has said that the cost of production is about five annas per pound. The selling price averages probably double this figure, so that there is a substantial margin of profit to work upon.

More than 80% of the mines are in lands from which Government claim a royalty on the mineral obtained. For the correct ascertainment of the revenue Government employ an official known as the mica inspector with two assistants. Each godown is visited monthly and the value of the mica ascertained before its despatch. All mica must be stored in godowns within one or two hundred yards of the mines. This provision prevents thefts of the mineral. Mica stealing used to be very common in the Bengal mica belt in 1902, but it is unknown in Nellore.

In most parts of Madras labour is very cheap. Managers receive about Rs. 15 per month; miners from 3 to 5 annas daily; women 2 annas and children 1 to $1\frac{1}{2}$ annas daily. The mica sorters and cutters have acquired considerable skill, and the whole of the output is despatched to market in regular sized rectangles, graded into various qualities. In the preparation of these films for the manufacture of micanite the delicate touch of women and children is found to be most effective.

Accidents are fortunately rare, the mortality per 1,000 being very much lower than the average figure for Indian mining. This is a fact highly creditable to the Managers. Taking into consideration the fact that they have evolved their own methods and are completely ignorant of any other style of mining, the working of the mines is carried on in a fairly creditable manner.

The author of the paper has referred to his discovery of manganese ore in the district. As the locality is within easy reach of a shipping port it would be interesting to know if the deposit is of commercial value. I hope he will supply further details.

Mr. Krishnaiya is hardly correct when he gives me the credit of identifying the mineral "Samarskite." It was through me that the discovery was brought to notice, but the identification was made by Mr. Blyth, Assistant Curator of the Geological Survey. I have here a specimen of the mineral and specimens also of mica pegmatite, garnetiferous pegmatite, mica, etc. Some of the mica it will be noticed has a beautiful iridiscence. I also exhibit a number of photographs of the mines. Should the Honorary Secretary think any of them would embellish the author's paper I am ready to lend the negatives for reproduction in the *Transactions*.

In reply to the queries addressed to me by Mr. Pringle I may inform him that the mica books occur in definite veins and usually at a definite horizon in the vein. The mica miner as a rule limits his excavations to such horizons. Mica is a stable mineral compound and little affected by weathering agencies. The oxidized zone is shallow and ill defined. Kaolinization of the felspars sometimes extends to a considerable depth, without the mica being affected. This fact in some mines facilitates the mining of the mica to a considerable degree, as explosives are not required and the yield of mica obtainable in a marketable condition is increased.

Neither the quality, size nor shape of the mica varies with the depth.

MR. KRISHNAIYA in reply says:—Dealing with Mr. Pringle's remarks I admit it is a remunerative industry if intelligent and economical methods of mining are employed, especially as depth is attained, and an attempt at location of a deposit is determined by a comparative study of the nature of occurrence of the mineral. It may not be out of place to add that besides the places covered by this paper, there exist some virgin taluqs which afford scope for mineral exploration.

"An amalgamation of interests is desirable." To the reference "if there is any defined leader," I would like to say that there is no uniformly constant leader.

The rock generally intervening between two books of mica is either quartz, felspar or pegmatite. After a book is won, the associated rock is blasted to open a fresh one. Generally, the course of mica is determined by that of the schist, in the case of a pegmatite vein. In a lens, it appears to be different. It may be added that in some mines a surprisingly systematic natural arrangement of books occurs—alternation of vertical and horizontal books of mica.

Size of mica does not always uniformly improve with depth. I think it more depends on the constituents of pegmatite—a predominance of good plagioclase being favourable. Occurrence of fine felspar and milky quartz afford encouragement. In big deposits, huge books were formed in the centre, while in others the size of books increased with depth.

There is no distinct oxidized zone or "water level." It depends on the level of the land worked, and proximity to natural streams or irrigation channels. Generally, water does not appear till over 50 feet are cut. The books found in water are absolutely unaltered, but are generally stiffer than those obtained near the surface.

Replying to Mr. Simpson:—I fully agree with Mr. Simpson's inferences regarding christening of mines in this district. That "many of the mines are called after Hindu deities who are presumed to exercise a benevolent influence over their fortunes" is true. This circumstance is I think associated with a few religious ideas. Firstly, the idea of an attempt to please a deity by naming the mine after it; secondly, that in consequence, it may exercise a beneficial influence over the riches of the mine; thirdly,

N.B.—The correct spelling of the name of the mine referred to by Mr. Simpson is "Sitaramanjaneyaswami."

respect for a particular deity who (the owner of a mine believes) has been guarding his family; and lastly, possibly an idea of obtaining salvation through frequent utterance of the name of the deity. "Counting beads" is a religious practice which has obtained much favour with the orthodox Brahman and Muhammadan.

With regard to transport the Madras Southern Marhatta Railway generally runs parallel to the mica belt, and the approaches to the railway stations are not as convenient as may be desired, but this inconvenience is minimised by the proximity of metalled roads which are, in most instances, within 10 miles, as Mr. Simpson rightly observes. On the other hand there are cases which unfortunately are not so well situated. Kavali is a railway station, and exports of mica to it have, at present, to go nearly 35 miles by metalled road.

I regret—with Mr. Simpson—the decline in the industry, and endorse his opinion that it is mostly due to lack of enterprise. I confidently hope for improvement this year. I think successful mining yields 50 per cent. net profit It may here be noted that initial investment on tools, etc., is very little.

The administrative control, *i.e.*, the supervision of mines, checking accounts, collection of Government revenue and reservation by the Mica Inspector (who has graduated in Geology) of unoccupied lands suspected to contain minerals is very effective, and zealously watches the interests of the Government. An adequate check is secured against fraud by the obligation of the miner to keep a daily register of his output, each mine having a separate register; *vide* Appendix B—Mica Mining Rules. It is a rule that mica won in a plot demised by a lease must be stored in a godown at the mine premises; and that though a lessee may own two or more quarries, mica must not be stored at one common centre until it is first stored at the mine from which it was extracted and the royalty duly paid. It is only after the proper observance of the rule that the products of different mines or quarries may be centralised at one place for storing purposes or otherwise.

It is gratifying to learn from Mr. Simpson that the mortality here is very low, and I think this is largely due to the annual inspection of an Inspector of Mines from the Department of Mines in India and the constant supervision of the local officers concerned.

The manganese-ore observed by me is of low grade, being highly siliceous. It occurs associated with pegmatite, and the exposed surface may be only a few square feet. So far as surface indications go, it does not seem to possess any commercial value. It would be a work of interest to investigate further details, but, I fear it may be regarded as being outside of the strict scope of my present official duties.

I am glad to be corrected by Mr. Simpson that it was Mr. Blyth, Assistant Curator of the Geological Survey, that identified "Samarskite." But, nevertheless, the effect of his (Mr. Simpson) having brought the discovery to notice cannot be too highly spoken of on account of the added interest it has given to mining in this part of the country. The desirability to improve my paper with photographs of the mines appealed strongly to me when I wrote it, and I accept with thanks Mr. Simpson's kind offer of his "negatives" for reproduction, and trust it is not too late to include them.

Discussion on Mr. H. A. Pringle's paper on "Notes on the Economics of Coal Mining in Bengal."

The author in reply to two or three members seeking information concerning working costs, expenditure, etc., said that he regretted that the experimental plant was not at present working. It had been erected at a colliery which was then on the point of closing down and which has since then ceased work altogether. The basket haulage plant was built almost entirely of old material then in disuse—it however was sufficiently stable to thoroughly demonstrate the efficacy of the system as was fully proved by the fact that it continued at work for some weeks during the final stages of closing down the colliery. The author then proceeded to point out that as Mr. Emmerson was present at the meeting and as that gentleman had installed and worked the experimental plant when he (Mr. Emmerson) was Manager at the said colliery, it was probable that members would like to have Mr. Emmerson's views on the subject.

Mr. Emmerson said that when the system was just started the coal-cutting price then ruling for coal cut and filled into tubs worked out at 10 annas per ton, and on that basis the price to be paid per basket under the new system was discussed, finally the actual price arranged was 4 pies per basket containing one maund (80 lbs.) of coal—this was equivalent to 3 maunds per anna or $9\frac{1}{3}$ annas per ton. After working at this rate for a week or 10 days a reduction in the rate was made and the price became 3 pies per basket, which worked out at about 7 annas per ton—a very substantial reduction on what hitherto had been paid—the collier and his mate cut the coal, filled the basket and carried it to the hanging-on station at the incline. A further point, which he was sure would be of interest to members, was that even at that rate the miners were able to station one of their own number permanently at the hanging-on station to count the number of baskets brought out from each working place—this man also assisted in lifting the baskets from the 'Kamin's head.'

Mr. J. R. R. Wilson :—A real type of check-weighman.

Mr. Emmerson (*continuing*) :—On one occasion one miner filled 80 baskets in one shift (from 8-30 A.M. to 4-30 P.M.), equal to nearly three tons—quite a record for the district On behalf of the company a 'Munshi' was placed at the hanging-on station to count the baskets and issue tokens in respect of same.

Mr. J. R. R. Wilson enquired as to the means adopted for releasing the rope from the clip both at the underground station and at surface.

Mr. Emmerson :—At the inbye end of the incline the gradient of the rail was changed at some little distance back from the return or tension pulley, and instead of inclining downwards at 1 in 10 it was fixed level. A coolie was stationed near that point provided with a fishplate, and with this he released the rope from the clip by inserting it below the rope and above the bar on which the baskets were suspended, then by depressing one end of the fishplate with the bar for a fulcrum the rope was raised from the dip; the baskets at that moment would be just about the point where the gradient changed, and they thus ceased to travel, having reached the level rail. They were then lifted off and passed to the full side by side.

Mr. Thomson :—At what speed did the rope travel, and at what distances apart was it possible to place the baskets on the rope ? How much coal could be raised from one such incline in a shift ?

Mr. Emmerson :—The speed varied from 60 to 80 feet per minute. There was no fixed distance because the output was a very small one, but the distance apart would naturally vary and depend on the activity displayed by the hangers-on.

In reply to a member concerning the surface arrangements—

Mr. Emmerson explained that the coal as raised was stacked, and for this purpose a coolie was employed to tip each basket as it passed him. This was done by releasing one of the loops of rope by which the basket was suspended—the coal then fell to the ground, the empty basket passing on until the top of the incline was reached, where a deflecting pulley caused the rope to be automatically released from the clip. The baskets and hanger or carrier were then placed on the opposite or full road and again entered the mine. Better arrangements could have been made if it had been necessary to communicate with the loading depot; but, as already stated, we were stacking the coal.

Mr. McMurtrie said it appeared to him that a great deal of timber would be used. He would like to know at what distance apart the uprights were placed seeing that the rail was only a light one, 10 lbs. per yard.

Mr. Emmerson replied that the rails used were 15 feet long and weighed 10 lbs. per yard, as stated; they were supported every $7\frac{1}{2}$ feet by an upright and cross tree. He believed however that Mr. Pringle had improved on that arrangement so that even less timber could be used.

Mr. Pringle in reply said that the question of output raised by Mr. Thomson was a very important one, and, needless to say, had been ever present throughout the conception of the scheme—economy, under the peculiar local conditions of mining in Bengal, being the key-note. *Speed of rope and spacing of baskets* jointly spelt output, and the flexibility of the system can best be realised when one remembers that the speed may be anything from one mile to three miles per hour and the spacing of units anything from a few feet to several yards. If loading an engine plane at half a dozen different stations, baskets can be attached at very close intervals. An output of 200 tons per day is well within reach. An amplification of the system is to have a double basket plane in one incline so that the left hand plane is fed by workings to the left and the right hand plane by workings on the right of the main incline. One engine suffices for both.

With regard to the supporting uprights, there were several ways of carrying the rail: a prop placed vertically and wedged between floor and thill is a convenient way; cast iron brackets or wrought iron hangers suspended from a transverse timber, set as a baulk to support the roof, is another form; but probably the best and simplest is the fixing into the sides at a proper height above the floor a single piece of timber about 3′ 6″ long × 5″ × 4″ let into the side say for two feet, leaving only 18″ projecting; on the end of this is placed the rail—these ‘plugs’ of timber could be placed at 5 feet intervals, and amply suffice.

The contributed notes by Mr. F. I. Leslie Ditmas arrived by mail from England after the second proofs of part 2, Vol. V, had been corrected We have however been able to secure them a place in this issue.—*Hon. Sec.*

F. I. Leslie Ditmas :—We are indebted to Mr. Pringle for bringing to our notice this novel way of dealing with the haulage question of coal. His paper is not only interesting but very original.

It is true that labour conditions are very different in India to those in other parts of the world, and had this basket single-rail system been introducted 10 or 15 years ago, it would probably have been very widely used. Personally I think it extremely clever, but behind the times.

During the past five years collieries have been brought more up to date, and the modern tendency is to have fewer inclines and larger outputs of coal from each incline.

The cost of Basket Haulage equipment (below ground) is given on page 52, Vol. 5, as Rs. 12,000, whilst that of Tub Haulage as Rs. 40,000 (for tubs alone), but surely 400 tubs is a fanciful number.

For example during the month of February, some three years ago, the Ashton Incline at Pench Valley hauled 7,300 tons (up this one incline) during 24 working days, with only 100 tubs in actual use (including those off for repairs). This at once brings down this part of the equipment cost to very much the same as that of the basket system.

It may be of interest to point out that at Chandametta Colliery there were several landings as well as flats, so that the actual carrying of coal was reduced to very short distances.

The tubs are filled by "fillers" who do not work in partnership with the hewers, so that the tubs were filled and drawn out as rapidly as possible.

Referring to page 54 we never found it necessary to "raise a full day's output in two or three hours." Sets of 10 tubs were drawn fairly regularly every hour, though of course some hours were more busy than others.

It is true that the cost of screening plant, etc., is far heavier with tub haulage.

With regard to the reference on page 55 concerning the possibility of the whole or part of a set running back into the pit, this very rarely happens with a suitable "dog" or trailer on a decently kept engine-plane.

There is one very important point which requires elucidation—How are the loaded baskets going to be checked and credited to the filler?

When a coal-cutter is content to fill one or two tubs a day, he or his kamin can claim it on the surface. The token system was tried at Pench but discarded after a time, as it was so difficult to check the changing and robbing of these. Pit writers were employed who wrote down the filler's name against each tub before the set was drawn away, and the number of tubs was compared with those passing over the tipplers at the screens.

There would, I think, be great difficulty in checking the enormous number of baskets filled and drawn out daily.

Owing to its lower total cost (surface and below ground included) the basket system may be employed in collieries worked by native owners, or where the capital is very small; but I question whether, despite its many ingenious qualities, it will be adopted in more than a few special cases by European firms aiming at a large output.

Mr. Pringle (*replying*) :—In criticising my figures comparing the capital outlay of the two systems of haulage, Mr. Ditmas has evidently had in mind his experiences in the Pench Valley coalfield. The output of the field is considerably under 100,000 tons per annum: the conditions of work are entirely different to Bengal; the local labourer has grown with the development of the Field and is not so full of fads as the Bengal miner: this is no doubt due to a better system of training, and Mr. Ditmas may fairly lay claim to whatever credit is due. It is, however, a well-known fact in the Bengal coalfields that the popular prejudice current with most miners is that he must start his shift with a tub in his working place, and in some places two tubs are demanded. Another popular idea with Managers is "one tub per ton per day" so that a 300 ton a day pit requires a stock of 300 tubs—it is a liberal basis—but where long distances and heavy grades obtain it works out pretty accurately.

The colliery quoted by Mr. Ditmas I am well acquainted with, and I am sure he will agree with me when I say it is in no way typical of Bengal practice. I wish it were. The point to which Mr. Ditmas attaches most importance, namely, the tallying of baskets, is one to which I confess I did not think it necessary to waste time over. I prefer to believe that if a system commends itself to colliery men as suitable to certain local conditions, the mere detail of keeping an account of each man's daily result might well be left to the intelligence of those in charge. The basket system is essentially suitable for low seams where 'carrying on the head' is impossible. At the collieries where Mr Ditmas was General Manager—Pench Valley—the miners are paid by the 'foot driven' and not, as in Bengal, by tonnage. Surely nothing could be simpler—no necessity to check the number of baskets from each place—the miner is paid by lineal measurement.

It was not within the scope of the paper to deal with every question incidental to the application of the system, but whilst in the subject of baskets and tubs I would direct attention to the aggregate number of baskets in the comparative table—8,000 in all: this provides for an average of 20 baskets per working place if all the places are occupied as compared with one tub per man. The individual miner would not get a receipt or a token for every basket—he would dispose of his wares in lots of 10, 15, or 20, and thus the "checking and crediting to the filler" need be no more cumbersome an operation than the present custom where tubs are in use.

As Mr. Ditmas very properly observes, the basket system may be employed where collieries are worked by small owners. I would add to that—and has a future where thin seams are worked: in other words, its application will be governed by local conditions. The most enthusiastic sponsor of anything new or approaching novelty must never expect more.

The Retirement of Mr. Wilson.

Mr. George Miller then read the following address:—

GENTLEMEN,—We learn with the deepest regret that this Institute is again to be made poorer by the departure of one of its most respected members to England. One who took the deepest interest in the welfare of this Institute enlivened the discussions from the generous store of knowledge possessed by him on the various subjects pertaining to mining. His advice and help in matters concerning the management of the Institute was, I am sure, always deeply appreciated by the Council.

Gentlemen, I refer to the Chief Mines Inspector, Mr. Wilson, whom I believe resigns his post as such in India and proceeds to England for good early in October. This meeting of the Institute will, in all probability, be the last one honoured with his presence. It may, therefore, I think be taken as a fitting occasion to thank Mr. Wilson for the services rendered to this Institute, as well as to express our profound regret at his departure. It is none the less regrettable that circumstances lead him to leave us after such a short stay. Mr. Wilson took office on 8th January 1908 as Chief of the Mines Department, and now takes his departure for the homeland. His predecessor, Mr. Pickering, found that circumstances and conditions of the Indian climate did not permit of any other decision, and his time amongst us was equally short.

It is very regrettable that our Chief Inspectors cannot be longer with us; such a short connection with the conditions of mining existing in India must at times make his work of administration somewhat difficult, his office for some time at least must be one of acquiring knowledge of the conditions under which we work. It may be assumed, therefore, that a considerable part of his service is spent in acquainting himself with our troubles and difficulties which cannot in a measure be considered light. The Mines Act which has been in force now since 1901 cannot be said to have lightened the burden of management of a mine in this country: it has, on the other hand, made the management of mines more efficient, and has undoubtedly introduced a care over the condition of the mine generally, and the people employed therein, which in many cases was previously unknown.

That the Act is yet incomplete, I am sure most will agree; as it stands it lays the responsibility on the shoulders of the Manager: it asks him to administer the law throughout his colliery, keep each individual in his proper place, and in fact teach him to do no wrong; but it gives no help to the Manager to deal with the breaker of the laws.

That a complete set of special rules is necessary is becoming more apparent daily.

The independent attitude of the labour and their utter disregard to orders and warnings is becoming a serious menace to the safe working of the mine, and this factor is responsible to a great extent for many of our fatal accidents. The Manager, as he is placed at present, has no power to enforce discipline amongst his employees except what he can administer by the end of a bamboo, and even this old homely method he is being deprived of to a great extent by the strict enforcement of the I. P. C. He therefore wants assistance in the administration of the rules and regulation of the Mines Act, and I trust our new Chief Inspector will turn his attention in this direction when he gets settled down into harness.

The rules must necessarily be identical in word and action at all mines. This is most important. The continual migration of the labour from one place to another, and their illiterate intellect, makes this condition imperative by an uniform set of rules being enforced. These men will learn in time to respect and keep these rules, whereas different rules at each different mine would defeat the purpose they were intended to perform.

We have been most fortunate in having for our Chief Mines Inspectors men of considerable experience as Mines Inspectors, men of practical training and knowledge who are open to give the fullest consideration to the difficulties under which the management of mines is carried out in India, and who by their quick adaptation to circumstances have made themselves masters of the situation and have gained the confidence of all.

It may not be our fortune, however, to have another such as the one who is about to say good-bye. It is therefore with diffidence we look upon a change. I think I am expressing the views of most mining men when I say that we look upon these many changes as not being in the best interests of the Industry, nor can I see wherein it can assist in the efficient administration of the office of Chief. Whoever Mr. Wilson's successor may be, he will be given a hearty welcome by this Institute and the industry generally. He has had an example shown by his predecessors that may well be followed by him—both these men leave our shores with a reputation that might well be envied, and it will live in the history of mining in this country.

It is to be hoped that our new Chief Inspector will come for a longer stay and not as a bird of passage.

When we consider the circumstances under which their adoption to this country takes place, however, it is not surprising to find the desire to return to the mother country. The Chief Mines Inspector must be a man of considerable experience in mining, and as a Mines Inspector a man of mature age and balanced mind, capable of dealing with the intricacies of his office and maintaining its dignity. It therefore follows that the man best capable and best able to fill this most important position must be a man of knowledge and ripe age. Unfortunately our Indian climate with its many discomforts does not appeal to such men, or appear so attractive as it might do to a younger man starting in life.

I am afraid, gentlemen, we are bound to conclude that we are to see yet another change if not continual changes after a short service and, therefore, a painfully short acquaintance ending on a hasty farewell such as we take from our friend Mr. Wilson today.

RESOLUTION.

"That the members of the Institute deeply regret the departure of Mr. Wilson, His Majesty's Chief Inspector of Mines of India, in whose departure we lose a valuable member of this Institute, as well as a capable adviser."

The resolution on being put to the Meeting was carried *nem con*, and members, with much enthusiasm, bade the Chief Inspector *bon voyage*.

Mr. J. R. R. WILSON replied :—I am exceedingly obliged Mr. Chairman, Mr. Miller and gentlemen for the resolution you have carried, and wish I had deserved the very flattering terms you have used. I will admit that I came to this country with certain ideas, certain ideals and hopes. Three years, after all, is a short space in the span of one's life, a very short time in which to affect a whole industry. At home one has been accustomed to look at the industry pretty much from the point of view of a country, whereas here the outlook is that of a continent; the distances are so great that it is difficult to keep in proper touch with things, certainly with the outskirts of the empire. Your conditions here too, as I have probably mentioned before, are so different from those in England. Nature has been very prodigal with her stores of fuel. Your labour, your methods of working, your administration, the Land Acquisition Mines Act, as related to the interesting though somewhat vexed question of support to be given to railways, all, or many of these, raise problems which are more or less new to one educated upon European lines.

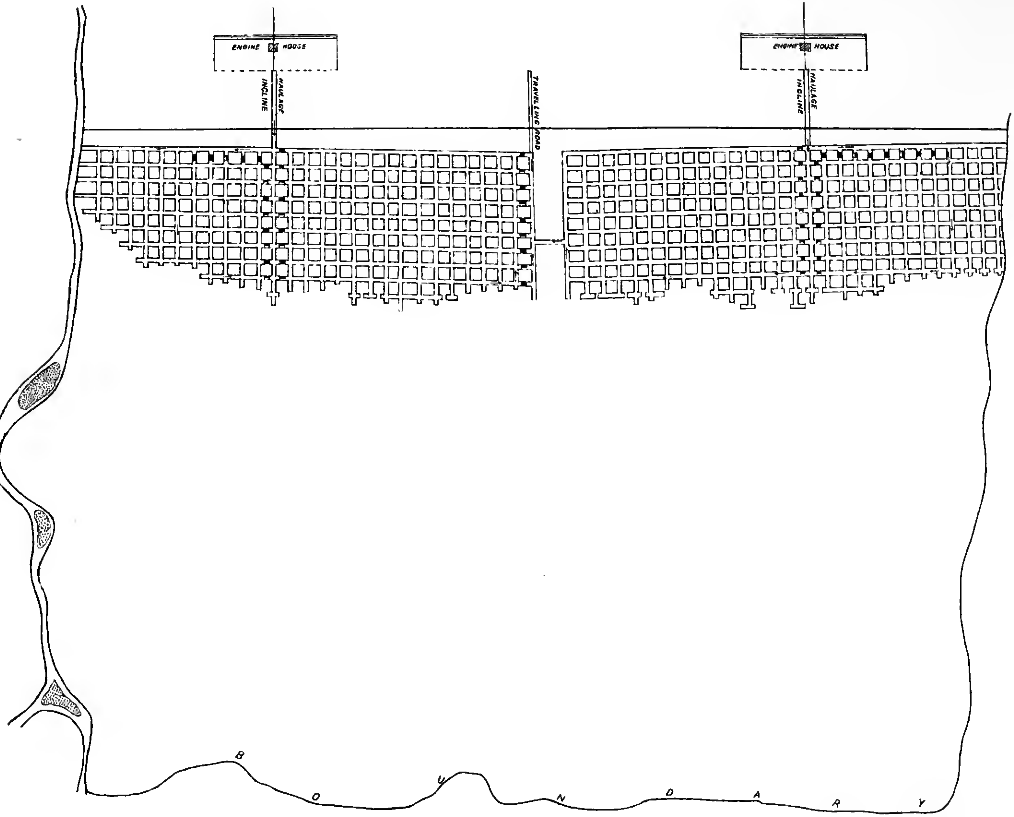
I can sympathise with the views expressed by Mr. Miller with regard to the position of the Chief Inspector of Mines, but I am afraid we are very much the creatures of circumstances. It is true that the first year is naturally one during which one has to grope with caution. The second year, one appreciates the fact that in so many cases the methods adopted are really suited to the conditions, and one can then only endeavour to effect improvements and give tone to proceedings which in a few cases one may consider are somewhat out of harmony. But, as you know, things move very slowly in India: the country as a whole apparently takes for its guide the old Latin motto "*festina lente*"—hasten slowly, which you would probably translate as "*aste jao*."

I am glad to hear the reference to special Rules and to observe that there is a desire to adopt a Code. I have been hammering at this for a long time. A good Code is ready: it is translated into the vernacular and only awaits the formality of adoption. Whenever I have mentioned it the individual has warmly approved of it, but he waits to see if his neighbour will also accept it. Everyone should accept it, and I had hoped that it would be done voluntarily; apparently my office will have to submit it under the clause of the Mines Act for universal acceptance. I should like to again draw your attention to the question of coal-dust. Your mines are certainly dusty, but in many cases they are also damp. These conditions will alter, and when one remembers your hard standstone roof and the way it falls, producing huge air-blasts with almost all the force of an explosion, it is not difficult to foresee what may happen if ever the blast stirring up the dust throughout the mine is accompanied by an ignition. If such does occur when men are in the mine, even "First Aid" will not be of much service to you. And what are you doing regarding the question of 'Ambulance Work.' Raniganj has given a lead and held some very successful classes. I hope before I leave you to see classes organised throughout the Jherria coal-field.

Gas is showing itself here and there in the mines: it has never been considered good mining practice to wait until a mine is destroyed before adopting safety lamps. But one may go on enumerating points that are of interest and importance. I cheerfully acknowledge that the conditions in Bengal have much improved: there is a keener interest in their work on the part of managers, and I am sure you have a bright future before you. Allow me to assure you that I value your appreciation of the little I have been able to do. I have received every courtesy and much kindness, and shall continue my interest in your work and look upon the days I have spent amongst you with considerable pleasure.

MINING AND GEOLOGICAL INSTITUTE OF INDIA.

GLEN GEORGE. Draft Plans for a Panel System. Transactions, Vol. V, Pl. 4.



PLAN No. I
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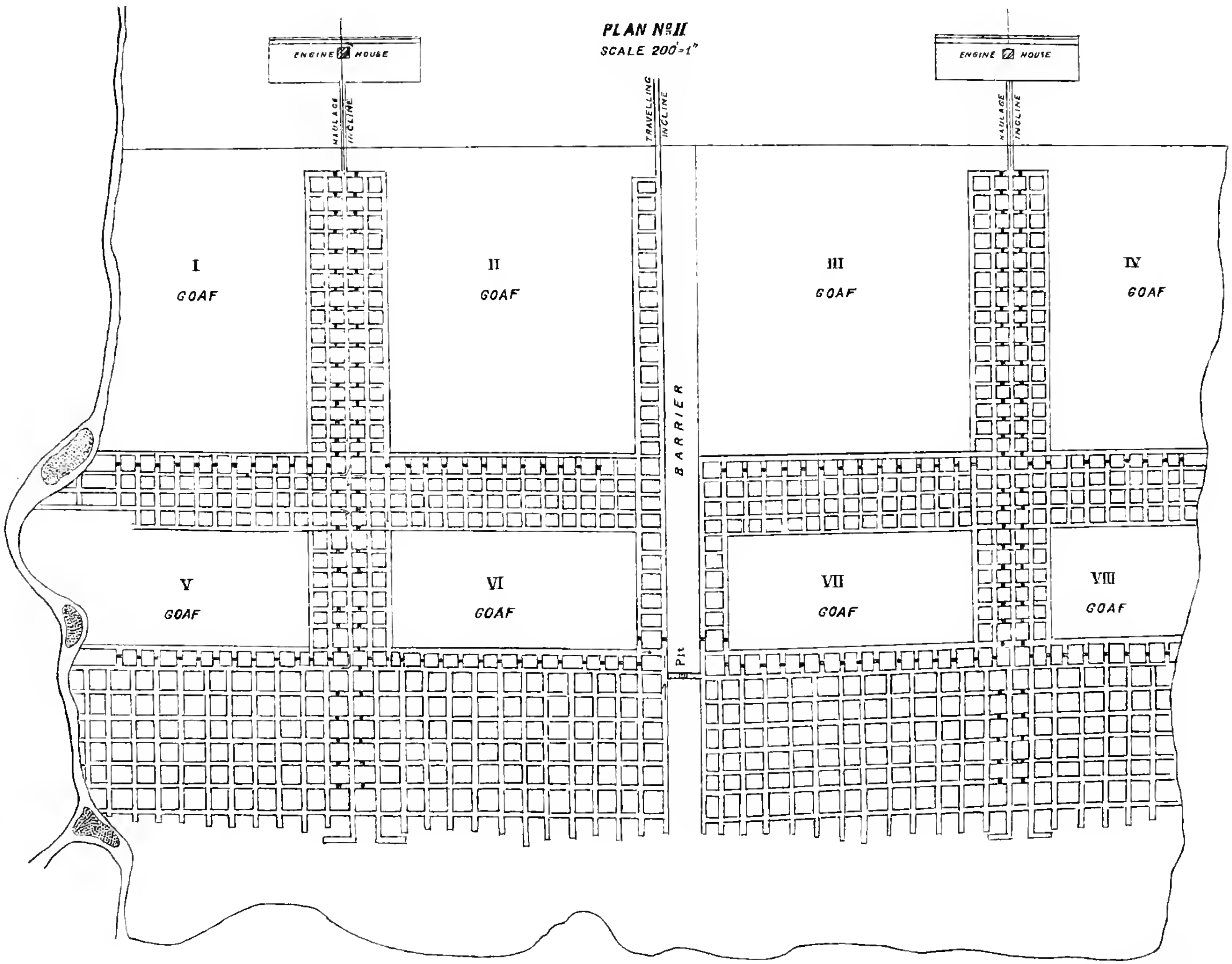
GLEN GEORGE. Draft Plans for a Panel System.

Transactions, Vol. V, Pl. 5.



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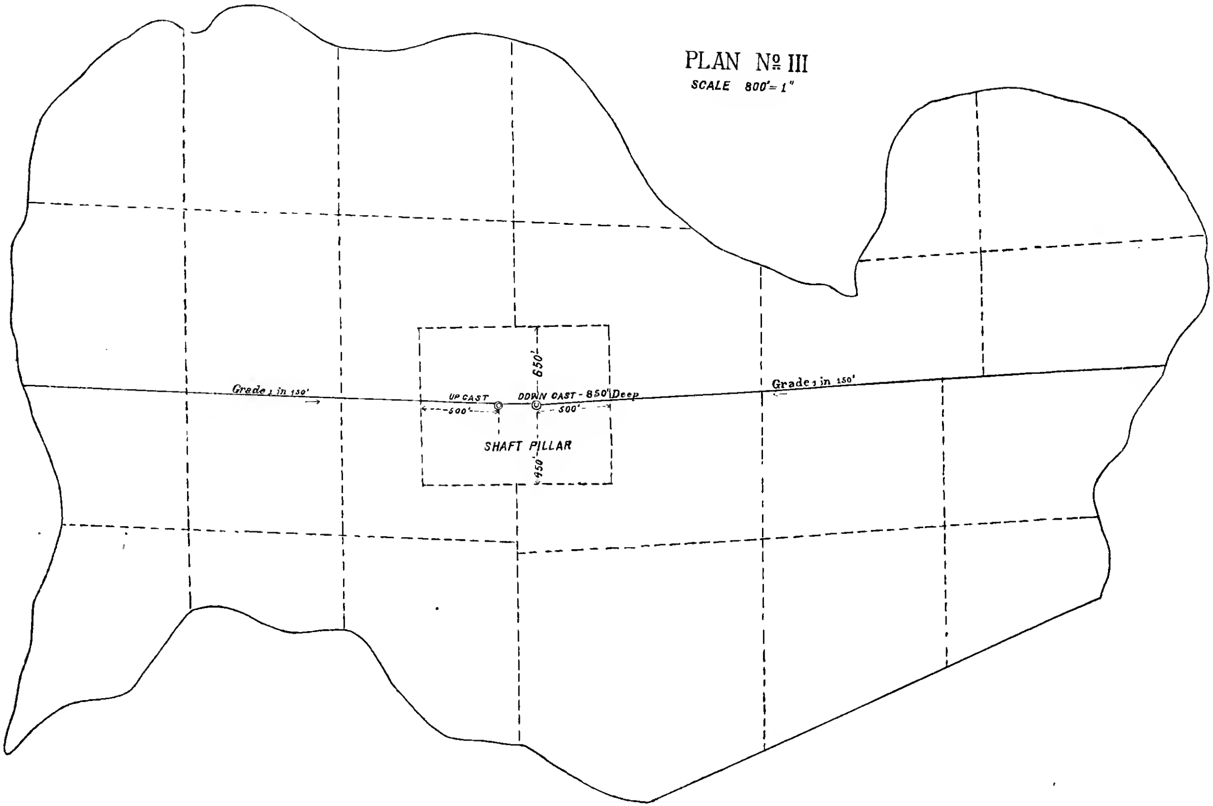

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GLEN GEORGE. Draft Plans for a Panel System. Transactions. Vol. V. Pl. 7.

PLAN No. IV

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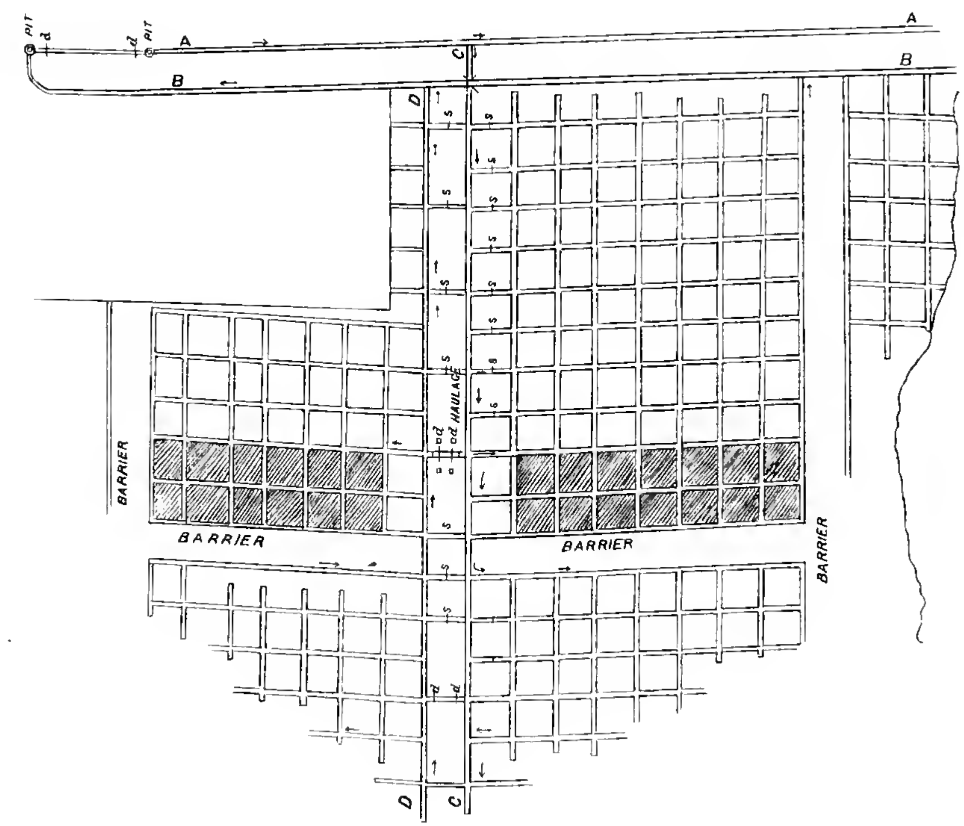

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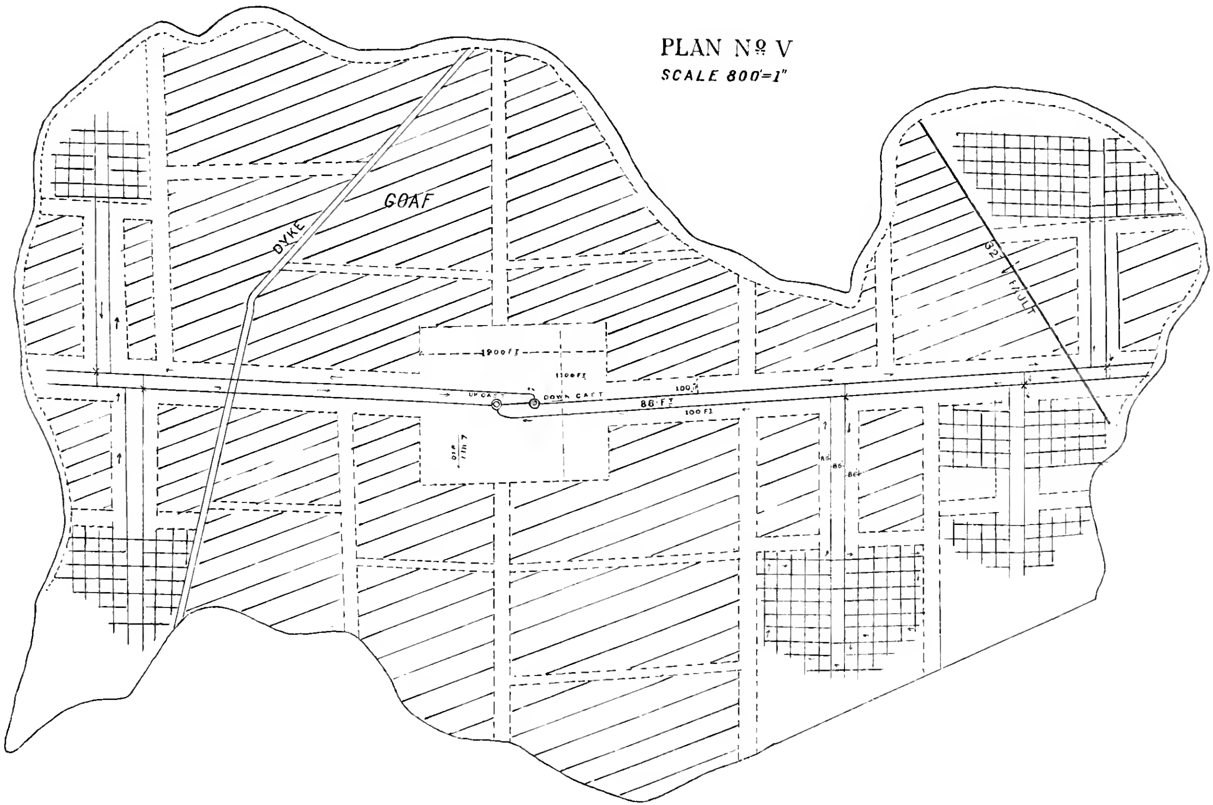
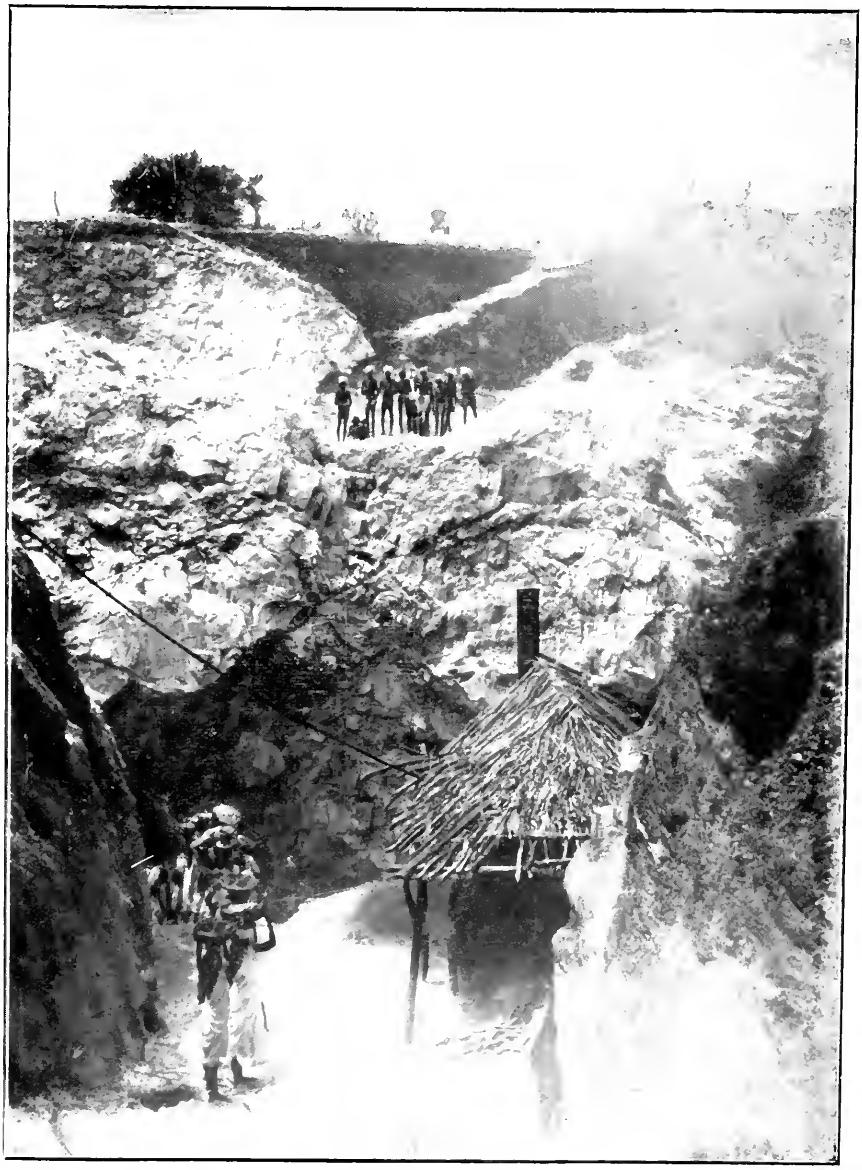
GLEN GEORGE. Draft Plans for a Panel System. Transactions. Vol. V. Pl. 8.



Lakshminarayana Mine.

A view of Lakshminarayana mine, at the surface, near the small tank, into which water pumped from the depths is discharged. The two pipes through which water flows are seen. At the end of the pipes a rectangular tank built of brick and mortar is situate. To the left of the pipes is a place for stacking firewood, used for feeding pumping engine. Under the shade of a tree in the spot, the "smithy stands." There is a small garden behind, and small flowering plants in it are exposed.

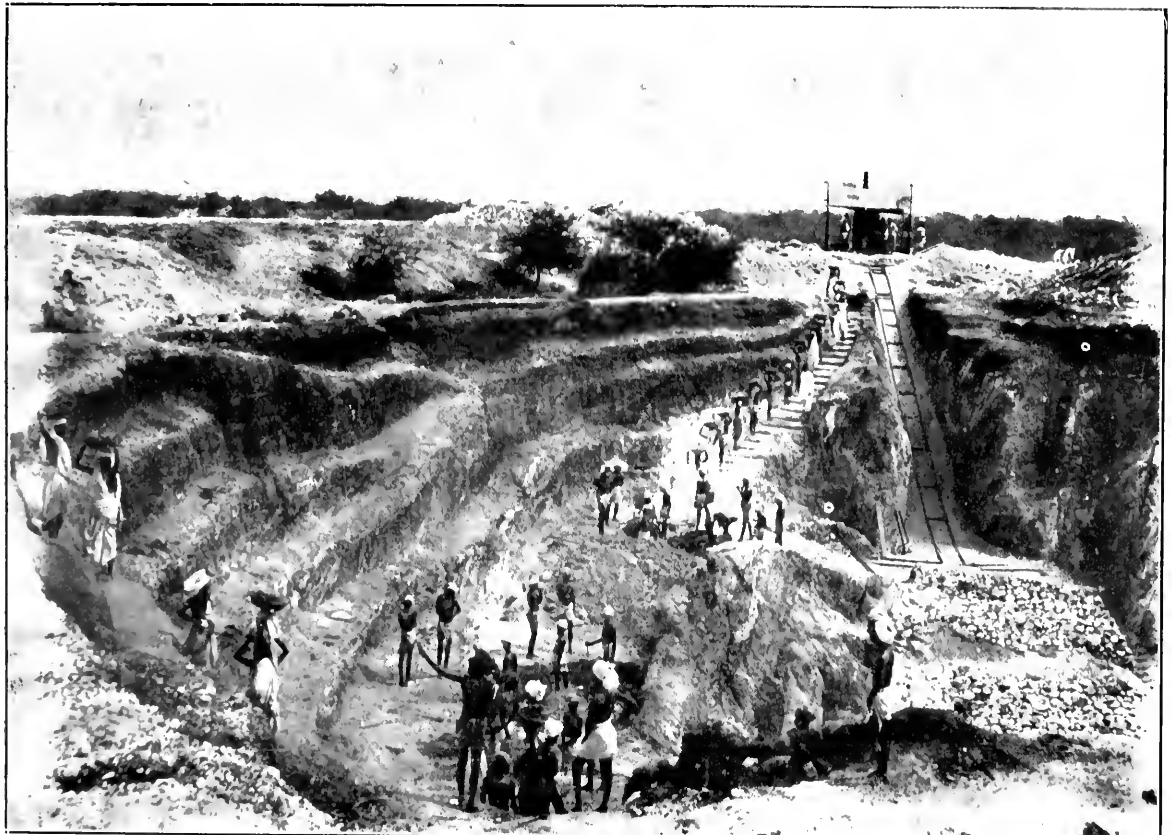


Lakshminarayana Mine.

A complete view of Lakshminarayana mine of Mr. R. Lakshminerasa Reddy. The thatched shed is the place where the oil-engine for pumping water is stationed. It is on a platform in the mine, about 30 feet from the surface. To the east of it there is a flight of steps to the surface, and the line of females working in the quarry are arrayed along it. Facing the engine, the exposed white rock is a huge mass of pegmatite, which is being attacked by the gang of labourers. Beyond that, in the background, stands a man on one of a flight of steps leading to the waste heaps where a tipping tub is placed to convey the blasted rock. To the left of the engine is a dark portion; it is an entrance to one of the tunnels in the mine.

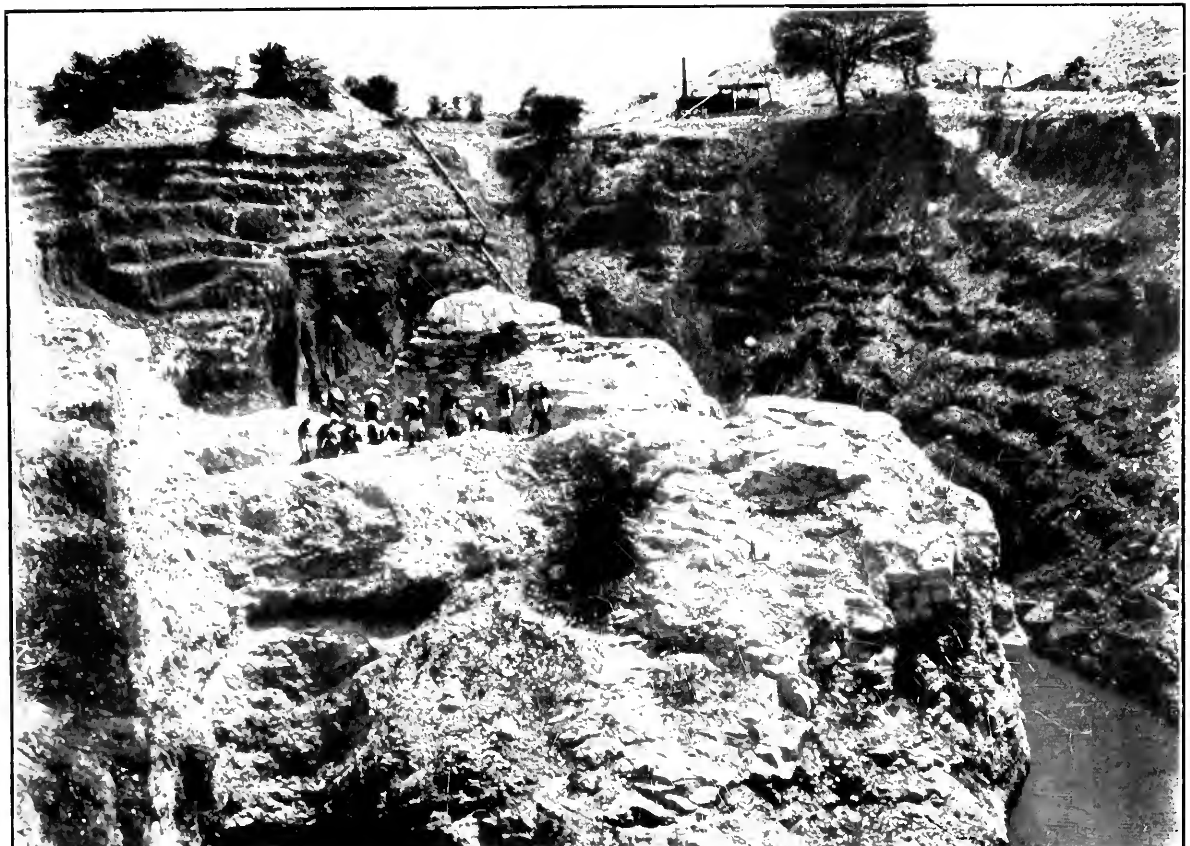
Lakshminarayana Mine.

Another view of Lakshminarayana mine. A stream of coolies is engaged in carrying to the surface pieces of blasted rock. Between it and the main mass of white pegmatite, lies an old roadway now abandoned.



Nandalagunta Mine.

A view of Nandalagunta mine of Messrs. Haji Md. Badsha Saheb & Co. of Madras. This is rather a big mine. There are two tunnels in it. Ahead there is an engine used for haulage. It is not now used. Light rails are spread in front of it to run ballast trucks on. There is a stream of labourers, some of whom are working with crow-bars, while others are engaged in transporting balasted material in small baskets along a flight of steps. The group of labourers below are about 30 feet from the surface. The stepping observed to the left of the labourers forms the western boundary of the mines and is mainly chlorite.

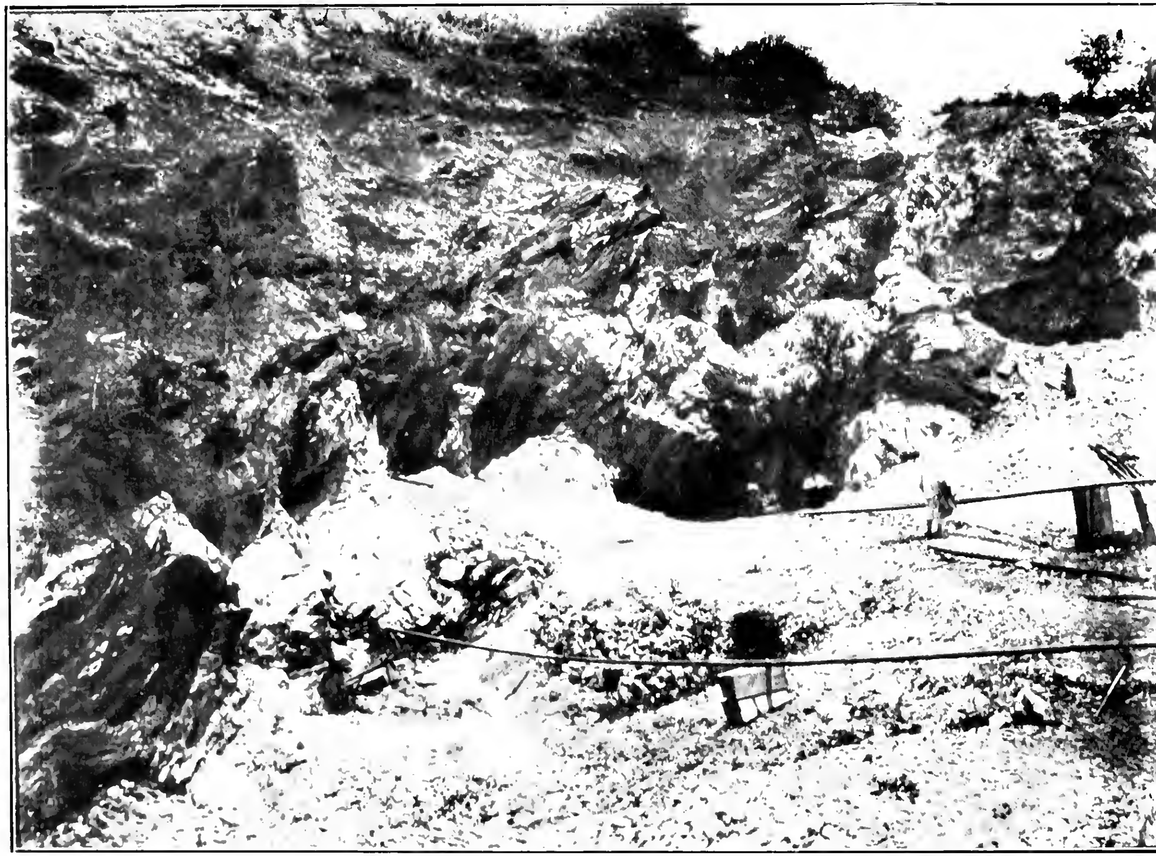


Inikurti Mine.

Inikurti or 'D' mine is one of the important mica mines. It is in the form of a long lens, and this picture represents the northern portion of it The mine is over 150 feet deep. There is a central mass of pegmatite which is being attacked; and it is almost an island, being surrounded by narrow trenches which yielded large quantities of silvery-white mica. In the background there is a thick pipe leading water from the mine to the surface. On the surface there is an engine posted to work out the water. Behind the engine there are waste dumps.

Inikurti Mine.

A view of Inikurti mine taken from the east. The central portion of this lens is being attacked by labourers. The stepping observed forms the western boundary, which is mainly mica-schist, but there is subsidiary hornblende and chlorite schist.



Tellabodu Mine.

A view of Tellabodu mine from its central plain. It is the biggest in the district, and yielded over 3,000 lbs. a day. The pipes are means of transporting water which is worked out mainly by suction-pumps. The height of the pipes from the surface will be over 60 feet. The dark rock noticed is schist, mainly of mica and quartzite.

Tellabodu Mine.

Another view of Tellabodu exposing its central plain. The indefinite contour of the opening to the left of the tipping tub marks the entrance of a big tunnel.

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